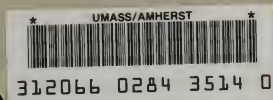
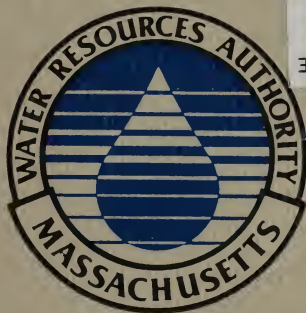


MASS. WRA1.2: Se25/2/draft/v.3/app.



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Secondary Treatment Facilities Plan

Volume III

Treatment Plant  
Appendices

**DRAFT REPORT**

November 13, 1987



Secondary Treatment Facilities Plan

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Appendices

# DRAFT REPORT

November 13, 1987





## **VOLUME III**

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## Appendix A



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Secondary Treatment Facilities Plan

Volume III

**Appendix A**  
**Inventory/Inspection**

## APPENDIX A INVENTORY/INSPECTION

Appendix A, the Inventory and Inspection of existing conditions at Deer Island, Nut Island and the remote headworks includes a detailed description and photographs of the existing facilities and is available for review at the Massachusetts Water Resources Authority in Charlestown, at Camp Dresser & McKee in Boston, and at Stone & Webster Engineering Corporation in Boston.

## **Appendix B**

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**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix B  
Sampling Program & QAQC**

#### Notes on the QA/QC Plan

The accompanying Quality Assurance Plan for sampling (QA/QC) was compiled in August of 1986 and distributed to the State, EPA, and MWRA for comment.

The described protocol was utilized for the Fall 1986 sampling. A second round of sampling included within the QA/QC document for the Spring of 1987 was conducted in accordance with the QA/QC plus revisions engendered by the results obtained in the fall. These revisions are detailed in Section 13 of this document.

A summary of the sampling results is given in Volume III, Section 6.1 of the report. The complete sampling results are contained within a four volume set that is on file at the MWRA.

## 1.0 INTRODUCTION

The Wastewater and Air Sampling Program is an integral part of the Massachusetts Water Resources Authority's (MWRA) Deer Island Facility Plan (DIFP) and Residuals Management Facility Plan (RMFP). The purpose of the Sampling Program is to obtain representative wastewater and air samples and then to maintain the integrity of the collected constituents. This document identifies the quality control and quality assurance steps required to achieve these goals. This document is structured in accordance with EPA's May 1984 "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring".

The references cited in this manual present the most effective and current laboratory analysis and field sampling practices. The procedures and techniques described are by no means the only methods available, but are those which are to be followed in this sampling project. Camp Dresser & McKee's (CDM) Laboratory standard of practice is available upon request. All methods not included in CDM's standard of practice are clearly explained in this document and have been developed by CDM personnel who have had experience in sampling and laboratory analysis.

## 2.0 PROJECT DESCRIPTION

### 2.1 GOALS

The sampling program is designed to produce data that can be used for three primary goals:

1. Evaluation of wastewater treatment plant processes exclusive of residuals (sludge) treatment, and inclusive of evaluation of outfall sites, nutrient potential, and conventional discharge permit parameters. This data will be used by the DIFP.
2. Evaluation of residual treatment and disposal alternatives by the RMFP. At this time, the RMFP is collecting data only on the wastewater, including parameters such as total solids, metals, and priority pollutants.
3. Evaluation of air quality impacts, primarily focused on the expected level of VOC emissions and the odor potential of the wastewater.

### 2.2 SAMPLING LOCATIONS

There are 6 influent sampling locations, 5 effluent sampling locations, and 3 air sampling locations that will be utilized. The use of each sampling location will be dependent upon both the type of sample being collected and the expected usage of the data from that portion of the sampling programs. The sampling locations are as follows:

#### South System Wastewater Sampling:

Influent to Nut Island Treatment Plant  
Effluent from Nut Island Treatment Plant  
(Prior to Chlorination)

#### North System Wastewater Sampling:

Influent to Columbus Park Headworks  
Influent to Chelsea Creek Headworks  
Influent to Ward Street Headworks  
Influent to Winthrop Terminal Headworks  
Influent to the Deer Island Plant  
Effluent from the Columbus Park Headworks  
Effluent from the Chelsea Creek Headworks  
Effluent from the Ward Street Headworks  
Effluent from the Deer Island Plant  
(Prior to Chlorination)

#### North System Air Sampling:

Columbus Park Tunnel Shaft  
Chelsea Creek Tunnel Shaft  
Ward Street Tunnel Shaft

The samples collected simultaneously from the four North System Headworks, when totaled, are equivalent to an influent sample to the Deer Island plant.

The sampling program will be divided into two flow periods. The first period will be 28 days in the late summer/early fall of 1986, and the second period will be 14 days in the spring of 1987. The late summer/early fall period was selected to give parameter values during a low groundwater period and the spring period was selected to monitor parameters during a high groundwater period.

### 2.3 STATEMENT OF SCOPE

#### 2.3.1 BOD<sub>5</sub>, TS, TSS, SETTLEABLE SOLIDS AND CHLORIDES

The conventional parameters, BOD<sub>5</sub>, TS, TSS, Settleable Solids, and Chlorides will be sampled at the influent to the four North System Headworks, and the influent to the two plants for 28 days in the first period and for 14 days in the second period. Samples will be collected as twenty-four hour composites and will be collected simultaneously.

These conventional parameters will also be sampled from the plant effluent for four days.

The data is primarily intended for the DIFP, but will also be utilized by the RMFP.

### 2.3.2 pH

The conventional parameter, pH, will be sampled at the North System Headworks for 3 days and for the next 25 days at the influent to the Deer Island plant, for a total of 28 days of sampling in the initial period. pH grab sampling will also be done at the influent to the Nut Island plant for the entire 28 days. In the second sampling period, pH will be sampled for 14 days at the influent to each of the plants.

Past data indicates that there is not a large fluctuation in pH levels at either plant. Therefore pH readings will be primarily taken upon delivery to the lab and will be supplemented by a limited program of grab samples at the collection sites.

### 2.3.3 OIL AND GREASE

The conventional parameter, oil and grease, will be sampled for a total of 14 days. All oil and grease samples will be during the first period. For the North System, grab samples will be collected at the headworks for 3 days and at the plant influent for the remaining 11 days. Samples will be taken for 14 days at the influent to the Nut Island plant. The data is primarily intended for the RMFP needs but will also be utilized by the DIFP.

### 2.3.4 PRIORITY POLLUTANTS, HSL ORGANICS, AND ORGANIC SCANS

Samples will be collected and then analyzed for Priority Pollutants (PP) including Hazardous Substance List (HSL) Organic Compounds. There are four distinct subsets under this category as follows:

- o Priority Pollutant List of PCB/Pesticides
- o Priority Pollutant and HSL List of Acid/and Base/Neutral (A-B/N) Extractables
- o Priority Pollutant List of Metals, Plus Boron Molybdenum and Cyanide
- o Priority Pollutants and HSL List of Volatile Organics

The PCB/Pesticides and Acid/Bases will be 24-hour flow composites, sampled during the first period at the influent to each of the North System Headworks for 3 days, and then at the influent to the Deer Island plant for the next four days, for a total of 7 days of samples. For the entire 7-day period, the influent to Nut Island will be sampled. For four days during that time, effluent samples will also be collected from both the Deer and Nut Island plants, to be used in conjunction with the Whole Effluent Toxicity (WET) program. The influents to the two plants will be sampled again for a total of 5 days during the second sampling period.

Twenty-four-hour composite sampling for priority pollutant metals will be done at the influent to the North System Headworks for three days, and the influent to the Deer Island plant for the next four days, for a total of seven continuous days. Samples will also be collected for the Nut Island influent for seven days. For four days, in conjunction with the WET program, effluent samples will be collected from both plants. After day seven, metal samples will be

collected an additional 11 times at the plants' influent, for a total of 18 days of metal samples in the first period. During the second (spring) period an additional 10 days of metal samples are to be collected from each plant's influent.

For Volatile Organics Analysis (VOA), the samples are required to be grab samples. The samples will either cover a 24-hour period during which 4 samples will be collected at 6-hour intervals, or a 12-hour period during which 2 samples will be collected at 6-hour intervals.

For the three remote headworks on the North System (Columbus Park, Chelsea Creek, and Ward Street), the VOA grab samples will be taken at both the influent and effluent of the headwork structure four times daily for 5 days, and then twice daily for three days thereafter. This will produce 26 total data points. The VOA samples at the headworks are intended to quantify VOA emission levels. However, due to an inability to collect a water sample off the wastewater as it directly enters the tunnel shaft at these three sites, there will be concurrent air monitoring for VOAs at these shaft locations. The sum of wastewater VOA and tunnel shaft air VOAs will then be compared to determine the estimated emission levels.

For the influent to the Winthrop Terminal Headworks, and the Nut Island influent, VOA samples will be collected four times daily for five days. During that five day sampling period, the effluents from both plants will also be sampled four times daily for VOAs.

For one daily sample at each site, the analysis will include identification of the twenty largest compounds that are at least 25% of the internal standard under the VOA and Acid/Base/Neutral portions, during the analytical scan. Samples will be screened for these additional compounds for the three days samples are collected from the North System Headworks; for the four days that samples are collected at the Deer Island plant influent; for the seven days of influent samples at the Nut Island plant; and the four days of effluent sampling at both plant sites.

### 2.3.5 COD/TOC, VSS, TS, TKN AND TOTAL PHOSPHORUS

The samples will be twenty-four hour flow composites collected daily. The program will collect samples for analysis of the process parameters COD/TOC, VSS, TS, TKN, and total phosphorous from the influent to the two plants for 14 days during the first period and for two days during the second period.

The analysis of COD and/or TOC is much more rapid than that for  $BOD_5$ . It is normally possible to establish a proportional relationship between these parameters so that if one is known the other two can be extrapolated. Therefore, during the first days of the sampling program both  $BOD_5$  and COD or TOC will be measured. Once the relationship is clearly established, from that point onward, only the COD or TOC analysis will be run. If after the relationship is established, an individual sample results in a COD or TOC reading that, in the opinion of the lab chemist, is abnormally high or low, then a  $BOD_5$  analysis will be run on a duplicate sample.

The samples will also be analyzed for ammonia nitrogen for four days in the first period and



for two days in the second period.

### 2.3.6 SULFIDES

One other process parameter to be sampled is sulfides. The sulfide samples will be grab samples collected four times daily and then composited into a daily sample for analysis. Samples will be collected for four days at the remote headworks and the influents to the two plants during the first period, and for two days in the second period at the influent to the two plants.

### 2.3.7 HYDROGEN SULFIDE

Air sampling of hydrogen sulfide will occur at Columbus Park, Ward Street, and Chelsea Creek Headworks and at the Deer Island and Nut Island plant sites. A hydrogen sulfide monitor with continuous chart recorder will be located at the headworks' operational level to monitor the working air environment.

### 2.3.8 SPLIT SAMPLES

For six consecutive days, including one weekend day, a split sampling program will be conducted. The daily influent composite samples and grab samples taken at Deer Island WWTP will be split between CDM's lab and the lab at Deer Island WWTP. A similar split sampling program will be done with the Nut Island WWTP lab. CDM will also, if requested, provide DEQE with split samples from these two locations.

A split sampling program will also, if requested, be conducted by CDM and DEQE with influent samples from the Columbus Park, Chelsea Creek, and Ward Street remote headworks.

The following split sample parameters will be analyzed:

<u>Parameter</u>	<u>Sample Type</u>
BOD <sub>5</sub>	24-hour composite
TSS	24-hour composite
Settleable Solids	24-hour composite
pH	Grab at 6-hour intervals - 4/day
Chlorides	24-hour composite
Oil & Grease	Grab at 6-hour intervals - 4/day

Each lab will receive approximately 1/2 gallon of the 24-hour composite and an oil and grease sample preserved in a separate container.

## 2.4 PURPOSE OF DATA

### 2.4.1 BOD<sub>5</sub> , TSS, SETTLEABLE SOLIDS, pH

These conventional parameters are required by both the Deer Island and the Residuals Management Facility Plan as a basis for evaluating alternatives.

The plant effluent is sampled for these parameters in coordination with the Whole Effluent Toxicity testing (WET) that is part of the outfall siting work.

### 2.4.2 OIL & GREASE

This data is primarily intended for the RMFP needs, but will be utilized by the DIFP.

### 2.4.3 PRIORITY POLLUTANTS AND ADDITIONAL HSL COMPOUNDS

#### PCB/Pesticides and Acid/Base-Neutral

Based upon past data, the expected levels of PCB/Pesticides and Acid/Base Neutrals are not expected to be the controlling variable for either the DIFP or the RMFP. Since there is little recent data, the sampling program will analyze for these compounds. The PCB data are needed for the outfall siting needs of the DIFP. The data will also be used by the RMFP to evaluate the acceptability of treated sludge as regulated by Massachusetts Land Application Regulations.

#### Metals

The level of metals are expected to be one of the controlling parameters for both the RMFP and the outfall siting portion of the DIFP. Therefore, in addition to the priority pollutant metals, analysis will also be conducted for boron, molybdenum and cyanide compounds. The list of metals to be analyzed was determined based upon the Massachusetts Land Application Regulations for sewage sludge and compost.

#### VOA

One of the primary goals of the VOA sampling is to quantify the amount of VOCs presently volatilizing at a specific site. The determination of VOC air emissions based on wastewater analysis is experimental at this time. The program seeks to identify a usable relationship between wastewater and air sampling and analysis. Influent and effluent will be sampled, from which it is expected that a difference can be calculated. At the headworks, the VOC in the exhaust air from the tunnel shafts will also be sampled. The air sample results will be used in combination with the wastewater values to quantify VOCs at the headworks. Data will then be used by the DIFP to evaluate the need for, and the magnitude of, ozone precursor controls. Data will also be used for a screening of air toxics based upon the State's Chem/AAL guidelines.



#### 2.4.4 COD/TOC, VSS, TS, TKN, TOTAL PHOSPHORUS, AMMONIA NITROGEN

This data will be used to evaluate treatment process design criteria. Criteria include the availability and level of nutrients present and needed to sustain biological treatment systems.

#### 2.4.5 SULFIDES

The sulfide content of the wastewater will be used to evaluate both its treatability and its  $H_2S$  odor potential.

#### 2.4.6 HYDROGEN SULFIDE

The purpose of continuously monitoring air levels of hydrogen sulfide at the headworks and the plants is to identify the operation periods when  $H_2S$  levels are maximum, to determine the time dependency of  $H_2S$  levels, to evaluate operator health and safety issues, and to provide a data base for proposed odor control equipment.

#### 2.4.7 SPLIT SAMPLES

The purpose of the split sampling program is to evaluate the homogeneity of samples, to compare results from different laboratories, to establish the margin of error of a lab procedure, and to establish a connection/relationship between this sampling program and the sources of historical treatment plant data (Nut Island lab and Deer Island lab).

### 2.5 MONITORING NETWORK DESIGN AND RATIONALE

#### 2.5.1 LOCATION RATIONALE

Samples taken at the Deer Island Treatment Plant influent will give parameter values that the proposed new plant site could experience. The reason for choosing the headworks sites is to determine by tributary components the loads from the MWRA system. Past data has been collected in the system; by industrial users; and as effluent data; but data has not been quantified for each tributary at the headworks.

#### 2.5.2 HOMOGENEITY OF SAMPLES

Sampling procedures have been designed so that samples taken are representative of the entire volume of wastewater passing the sampling location. Actual sampling procedures are covered in Section 7.

### 2.6 MONITORING PARAMETERS AND ANALYTICAL METHODS

Tables B-1 through B-5 list all the parameters for which the wastewater will be analyzed. The type of sample, sampling orientation to the water surface, sampling frequency, and analytical

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY PARAMETER

Conventional Parameters	Sample Type	Water Surface (WS) Sampling Orientation <sup>4</sup>	Sampling Frequency <sup>3</sup>	Analytical Method
BOD 5 day	24 Hr Composite	Below WS	1/hr Min	507 <sup>1</sup>
Total Solids	24 Hr Composite	Below WS	1/hr Min	160.3 <sup>2</sup>
Total Suspended Solids	24 Hr Composite	Below WS	1/hr Min	160.2 <sup>2</sup>
Total Volatile Suspended Sol	24 Hr Composite	Below WS	1/hr Min	160.4 <sup>2</sup>
Settleable Solids	24 Hr Composite	Below WS	1/hr Min	209E <sup>1</sup>
Chemical Oxygen Demand	24 Hr Composite	Below WS	1/hr Min	410.4 <sup>2</sup>
Total Organic Carbon	24 Hr Composite	Below WS	1/hr Min	415.2 <sup>2</sup>
Chloride	24 Hr Composite	Below WS	1/hr Min	300 <sup>2</sup>
Total Kjeldahl Nitrogen	24 Hr Composite	Below WS	1/hr Min	351.3 <sup>2</sup>
Ammonia	24 Hr Composite	Below WS	1/hr Min	350.2 <sup>2</sup>
Sulfide	Grab	Below WS	4/day	376.1 <sup>2</sup>
Oil and Grease	Grab	Includes WS	4/day	413.1 <sup>2</sup>
Total Phosphorus	24-Hr Composite	Below WS	1/Hr Min	365.2 <sup>2</sup>
Total Nitrogen	24 Hr Composite	Below WS	1/hr Min	

<sup>1</sup> Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.

<sup>2</sup> Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.

<sup>3</sup> Samples are to be collected daily on a 24-hour flow composited basis at influent to headworks with a minimum sample collection of once per hour. Plant effluent samples will be time composited hourly and then each hourly sample will be flow composited based upon recorded flows that hour.

<sup>4</sup> Samples below water surface are samples collected from within the moving water and do not include any floating film.

TABLE B-2

## SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY METAL

<u>Metals</u>	<u>Water Surface (WS) Sample Type</u>	<u>Sampling<sup>2</sup> Sampling Orientation</u>	<u>Analytical Frequency</u>	<u>Method<sup>1</sup></u>
Antimony	24 Hr Composite	Below WS	1/hr Min	204.2
Arsenic	24 Hr Composite	Below WS	1/hr Min	206.2
Beryllium	24 Hr Composite	Below WS	1/hr Min	210.2
Boron	24 Hr Composite	Below WS	1/hr Min	404.B <sup>1</sup>
Cadmium	24 Hr Composite	Below WS	1/hr Min	213.2
Chromium	24 Hr Composite	Below WS	1/hr Min	218.2
Copper	24 Hr Composite	Below WS	1/hr Min	220.2
Cyanide	24 Hr Composite	Below WS	1/hr Min	335.2 <sup>3</sup>
Lead	24 Hr Composite	Below WS	1/hr Min	239.2
Mercury	24 Hr Composite	Below WS	1/hr Min	245.1
Molybdenum	24 Hr Composite	Below WS	1/hr Min	246.2 <sup>3</sup>
Nickel	24 Hr Composite	Below WS	1/hr Min	249.2
Selenium	24 Hr Composite	Below WS	1/hr Min	270.2
Silver	24 Hr Composite	Below WS	1/hr Min	272.2
Thallium	24 Hr Composite	Below WS	1/hr Min	279.2
Zinc	24 Hr Composite	Below WS	1/hr Min	289.2

TABLE B-2

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY METAL  
(Continued)

- <sup>1</sup> All methods contained in Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1987.
- <sup>2</sup> Samples are to be collected daily on a 24-hour flow composited basis at influent to headworks with a minimum sample collection of once per hour. Plant effluent samples will be time composited hourly and then each hourly sample will be flow composited based upon recorded flows for that hour.
- <sup>3</sup> Standard Methods for the examination of Water and Wastewater, 16th edition, 1985.

TABLE B-3

## SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS

Volatile Organic Compounds	Water Surface (WS)		Sampling <sup>1</sup> Frequency	Analytical Method
	Sample Type	Sampling Orientation		
<u>Priority Pollutants</u>				
Chloromethane	Grabs	Includes WS	2 or 4/day*	40 CFR
Bromomethane	Grabs	Includes WS	2 or 4/day*	Part 136
Vinyl Chloride	Grabs	Includes WS	2 or 4/day*	Friday,
Chloroethane	Grabs	Includes WS	2 or 4/day*	Oct 26, 1984
Methylene Chloride	Grabs	Includes WS	2 or 4/day*	Method 624
Trichlorofluoromethane	Grabs	Includes WS	2 or 4/day*	
1,1-Dichloroethylene	Grabs	Includes WS	2 or 4/day*	
1,1-Dichloroethane	Grabs	Includes WS	2 or 4/day*	
Trans-1,2-Dichloroethylene	Grabs	Includes WS	2 or 4/day*	
Chloroform	Grabs	Includes WS	2 or 4/day*	
1,2-Dichloroethane	Grabs	Includes WS	2 or 4/day*	
1,1,1-Trichloroethane	Grabs	Includes WS	2 or 4/day*	
Carbon Tetrachloride	Grabs	Includes WS	2 or 4/day*	
Bromodichloromethane	Grabs	Includes WS	2 or 4/day*	
1,2-Dichloropropane	Grabs	Includes WS	2 or 4/day*	
Trans-1,3-Dichloropropene	Grabs	Includes WS	2 or 4/day*	
Trichloroethylene	Grabs	Includes WS	2 or 4/day*	
Dibromochloromethane	Grabs	Includes WS	2 or 4/day*	
CIS-1,3-Dichloropropene	Grabs	Includes WS	2 or 4/day*	
1,1,2-Trichloroethane	Grabs	Includes WS	2 or 4/day*	

TABLE B-3

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS  
(Continued)

Volatile Organic Compounds	Water Surface (WS)		Sampling Orientation	Sampling <sup>1</sup> Frequency	Analytical Method
	Sample Type				
Priority Pollutants					
Benzene	Grabs		Includes WS	2 or 4/day*	
2-Chloroethylvinylether	Grabs		Includes WS	2 or 4/day*	
Bromoform	Grabs		Includes WS	2 or 4/day*	
Tetrachloroethylene	Grabs		Includes WS	2 or 4/day*	
1,1,2,2-Tetrachloroethane	Grabs		Includes WS	2 or 4/day*	
Toluene	Grabs		Includes WS	2 or 4/day*	
Chlorobenzene	Grabs		Includes WS	2 or 4/day*	
Ethylbenzene	Grabs		Includes WS	2 or 4/day*	
Add'l Hazardous Substances List Compounds					
Styrene	Grabs		Includes WS	2 or 4/day*	
Total Xylenes	Grabs		Includes WS	2 or 4/day*	
Carbon Disulfide	Grabs		Includes WS	2 or 4/day*	
Vinyl Acetate	Grabs		Includes WS	2 or 4/day*	
2-Butanone	Grabs		Includes WS	2 or 4/day*	
Acetone	Grabs		Includes WS	2 or 4/day*	
2-Hexanone	Grabs		Includes WS	2 or 4/day*	
4-Methyl-2-Pentanone	Grabs		Includes WS	2 or 4/day*	

<sup>1</sup> Grab samples will be taken at 6-hour intervals. Selected days will be sampled four times over a 24-hour period. At other times samples over a 12-hour period will be sampled.



TABLE B-4

## SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS

Acid/Base/Neutral Compounds	Sample Type	Water Surface (WS) Sampling Orientation	Sampling Frequency	Analytical Method
N-Nitrosodimethylamine	24 Hr Composite	Below WS	1/hr Min	40 CFR
Phenol	24 Hr Composite	Below WS	1/hr Min	Part 136
Aniline	24 Hr Composite	Below WS	1/hr Min	Friday,
Bis(2-Chloroethyl)Ether	24 Hr Composite	Below WS	1/hr Min	Oct 26, 1984
2-Chlorophenol	24 Hr Composite	Below WS	1/hr Min	Method 625
1,3-Dichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
1,4-Dichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
Benzyl Alcohol	24 Hr Composite	Below WS	1/hr Min	
1,2-Dichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
2-Methylphenol	24 Hr Composite	Below WS	1/hr Min	
Bis(2-Chloroisopropyl)Ether	24 Hr Composite	Below WS	1/hr Min	
4-Methylphenol	24 Hr Composite	Below WS	1/hr Min	
N-Nitroso-Di-N-Propylamine	24 Hr Composite	Below WS	1/hr Min	
Hexachloroethane	24 Hr Composite	Below WS	1/hr Min	
Nitrobenzene	24 Hr Composite	Below WS	1/hr Min	
Isophorone	24 Hr Composite	Below WS	1/hr Min	
2-Nitrophenol	24 Hr Composite	Below WS	1/hr Min	
2,4-Dimethylphenol	24 Hr Composite	Below WS	1/hr Min	
Benzoic Acid	24 Hr Composite	Below WS	1/hr Min	
Bis(2-Chloroethoxy)Methane	24 Hr Composite	Below WS	1/hr Min	
2,4-Dichlorophenol	24 Hr Composite	Below WS	1/hr Min	
1,2,4-Trichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
Naphthalene	24 Hr Composite	Below WS	1/hr Min	
4-Chloroaniline	24 Hr Composite	Below WS	1/hr Min	
Hexachlorobutadiene	24 Hr Composite	Below WS	1/hr Min	
P-Chloro-M-Cresol	24 Hr Composite	Below WS	1/hr Min	

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS  
(Continued)

Acid/Base/Neutral Compounds	Sample Type	Water Surface (WS) Sampling Orientation	Sampling Frequency	Analytical Method
2-Methylnaphthalene	24 Hr Composite	Below WS	1/hr Min	
Hexachlorocyclopentadiene	24 Hr Composite	Below WS	1/hr Min	
2,4,6-Trichlorophenol	24 Hr Composite	Below WS	1/hr Min	
2,4,5-Trichlorophenol	24 Hr Composite	Below WS	1/hr Min	
2-Chloronaphthalene	24 Hr Composite	Below WS	1/hr Min	
2-Nitroaniline	24 Hr Composite	Below WS	1/hr Min	
Dimethyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
Acenaphthylene	24 Hr Composite	Below WS	1/hr Min	
3-Nitroaniline	24 Hr Composite	Below WS	1/hr Min	
Acenaphthene	24 Hr Composite	Below WS	1/hr Min	
2,4-Dinitrophenol	24 Hr Composite	Below WS	1/hr Min	
4-Nitrophenol	24 Hr Composite	Below WS	1/hr Min	
Dibenzofuran	24 Hr Composite	Below WS	1/hr Min	
2,4-Dinitrotoluene	24 Hr Composite	Below WS	1/hr Min	
2,6-Dinitrotoluene	24 Hr Composite	Below WS	1/hr Min	
Diethyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
4-Chlorophenyl Phenyl Ether	24 Hr Composite	Below WS	1/hr Min	
Fluorene	24 Hr Composite	Below WS	1/hr Min	
4-Nitroaniline	24 Hr Composite	Below WS	1/hr Min	
4,6-Dinitro-2-Methylphenol	24 Hr Composite	Below WS	1/hr Min	



TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS  
(Continued)

Acid/Base/Neutral Compounds	Water Surface (WS)		Sampling Orientation	Sampling Frequency	Analytical Method
	Sample Type				
N-Nitrosodiphenylamine	24 Hr Composite	Below WS	1/hr Min	40 CFR	
4-Bromophenyl Phenyl Ether	24 Hr Composite	Below WS	1/hr Min	Part 136	
Hexachlorobenzene	24 Hr Composite	Below WS	1/hr Min	Friday,	
Phenanthrene	24 Hr Composite	Below WS	1/hr Min	Oct 26, 1984	
Anthracene	24 Hr Composite	Below WS	1/hr Min	Method 625	
Di-N-Butyl Phthalate	24 Hr Composite	Below WS	1/hr Min		
Fluoranthene	24 Hr Composite	Below WS	1/hr Min		
Benzzidine	24 Hr Composite	Below WS	1/hr Min		
Pyrene	24 Hr Composite	Below WS	1/hr Min		
Butylbenzyl Phthalate	24 Hr Composite	Below WS	1/hr Min		
3,3-Dichlorobenzidine	24 Hr Composite	Below WS	1/hr Min		
Benzo(A)Anthracene	24 Hr Composite	Below WS	1/hr Min		
Bis(2-Ethylhexyl)Phthalate	24 Hr Composite	Below WS	1/hr Min		
Chrysene	24 Hr Composite	Below WS	1/hr Min		
Di-N-Octyl Phthalate	24 Hr Composite	Below WS	1/hr Min		
Benzo(B)Fluoranthene	24 Hr Composite	Below WS	1/hr Min		
Benzo(K)Fluoranthene	24 Hr Composite	Below WS	1/hr Min		
Benzo(A)Pyrene	24 Hr Composite	Below WS	1/hr Min		
Indeno(1,2,3-C,D)Pyrene	24 Hr Composite	Below WS	1/hr Min		
Dibenzo(A,H)Anthracene	24 Hr Composite	Below WS	1/hr Min		
Benzo(G,H,I)Perylene	24 Hr Composite	Below WS	1/hr Min		

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS  
(Continued)

PCB/PESTICIDE ANALYSIS	Water Surface (WS)		Sampling Orientation	Sampling Frequency	Analytical Method
	Sample Type				
<u>Compound</u>					
Aldrin	24 Hr Composite	Below WS	1 hr/Min		
Alpha-BHC	24 Hr Composite	Below WS	1 hr/Min		
Beta-BHC	24 Hr Composite	Below WS	1 hr/Min		
Gamma-BHC	24 Hr Composite	Below WS	1 hr/Min		
Delta-BHC	24 Hr Composite	Below WS	1 hr/Min		
Technical Chlordane	24 Hr Composite	Below WS	1 hr/Min		
4,4-DDT	24 Hr Composite	Below WS	1 hr/Min		
4,4-DDE	24 Hr Composite	Below WS	1 hr/Min		
4,4-DDD	24 Hr Composite	Below WS	1 hr/Min		
Dieldrin	24 Hr Composite	Below WS	1 hr/Min		
Endosulfan I	24 Hr Composite	Below WS	1 hr/Min		
Endosulfan II	24 Hr Composite	Below WS	1 hr/Min		
Endosulfan Sulfate	24 Hr Composite	Below WS	1 hr/Min		
Endrin	24 Hr Composite	Below WS	1 hr/Min		

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS  
(Continued)

Acid/Base/Neutral Compounds	Sample Type	Water Surface (WS) Sampling Orientation	Sampling Frequency	Analytical Method
<u>PCB/PESTICIDE ANALYSIS</u>				
Endrin Aldehyde	24 Hr Composite	Below WS	1 hr Min	40 CFR
Endrin Ketone	24 Hr Composite	Below WS	1 hr Min	Part 136
Heptachlor	24 Hr Composite	Below WS	1 hr Min	Friday,
Heptachlor Epoxide	24 Hr Composite	Below WS	1 hr Min	Oct 26, 1984
Methoxychlor	24 Hr Composite	Below WS	1 hr Min	Method 608
Arochlor 1016	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1221	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1232	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1242	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1248	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1254	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1260	24 Hr Composite	Below WS	1 hr Min	
Toxaphene	24 Hr Composite	Below WS	1 hr Min	

method are also listed.

Table B-6 lists the parameters for which air from the headworks tunnel shafts will be analyzed. The type of sample, sampling frequency, and analytical method are also listed.

### 3.0 PROJECT FISCAL INFORMATION

This sampling program is one element of the Deer Island Facility Plan. The scope of work, budget, and funding for the Facility Plan are contained within a separate document titled "Detailed Work Plan for Deer Island Secondary Treatment Facilities Plan". The budgets and scope description of the sampling program can be found within Work Package FB-20C of that document.

### 4.0 SCHEDULE OF TASKS AND PRODUCTS

The task schedule for the sampling project is as follows:

<u>Date</u>	<u>Task Description</u>
July 15, 1986	Sampling site visit by CDM personnel.
July 25, 1986	Outline signal and power needs to MWRA.
August 8, 1986	Signal and power available at the sampling sites. Equipment installation starts.
August 11, 1986	Start of the trial sampling period.
August 13, 1986	First sampling period begins.
September 10, 1986	First sampling period ends.
October 30, 1986	First sampling period report data.
March 1, 1987	Begin second sampling period.
March 21, 1987	End second sampling period.
May 30, 1987	Second period sampling data available, final memo prepared.

TABLE B-6

# AIR SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUND

<u>Volatile Organic Compounds</u>	<u>Sample Type</u> <sup>1</sup>	<u>Sampling</u> <sup>2</sup> <u>Frequency</u>	<u>Analytical</u> <sup>3</sup> <u>Method</u>
<u>Priority Pollutants</u>			
Bromomethane	Grabs	4/day	2520
Vinyl Chloride	Grabs	4/day	1007
Methylene Chloride	Grabs	4/day	1005
1,1-Dichloroethylene	Grabs	4/day	1003
Trans.-1,2-Dichloroethylene	Grabs	4/day	1003
Chloroform	Grabs	4/day	1003
1,2-Dichloroethane	Grabs	4/day	1003
1,1,1-Trichloroethane	Grabs	4/day	1003
Carbon Tetrachloride	Grabs	4/day	1003
Trichloroethylene	Grabs	4/day	S336
Benzene	Grabs	4/day	1501
Bromoform	Grabs	4/day	1003
Toluene	Grabs	4/day	1501
Chlorobenzene	Grabs	4/day	1003
Ethylbenzene	Grabs	4/day	1501
<u>Additional Hazardous Substances List Compounds</u>			
Styrene	Grabs	4/day	1501
Total Xylenes	Grabs	4/day	1501
2-Butanone	Grabs	4/day	2500
Acetone	Grabs	4/day	1300
2-Hexanone	Grabs	4/day	1300
4-Methyl-2-Pentanone	Grabs	4/day	1300

<sup>1</sup> An initial screening using both Tedlar bag samples and NIOSH carbon adsorption/desorption samples will be collected and analyzed. Flow rates will be monitored also. A determination will be made as to accuracy of both methods, and the actual methods, and the actual samples will be run on selected method.

<sup>2</sup> Grab samples will be taken at 6-hour intervals.

<sup>3</sup> Analytical methods referenced are NIOSH methods. Results will be reported with percent recovery and carbon will be separately analyzed for front end and back end to monitor for breakthrough.

## 5.0 PROJECT ORGANIZATION AND RESPONSIBILITY

Figure B-1 shows the project organization chart.

In brief, each individual's role can be described as follows:

**WILLIAM F. CALLAHAN** (Senior Vice President/CDM): Monitors overall project to assure applicability of sampling to other tasks in the MWRA Facility Plan effort.

**STEPHEN D. RAFFERTY** (Project Manager/CDM): Has overall responsibility for the day-to-day sampling program.

**DONALD MULDOON** (Laboratory Manager/CDM): Overall responsibility for CDM lab work and outside laboratories.

**JAMES F. OCCHIALINI** (Laboratory Supervisor/CDM): Responsible for day-to-day CDM lab work. Author of lab portion of QA/QC plan.

**LAB CHEMISTS** - CDM has 10 chemists who will perform the sample analysis. Approximately 5 of the chemists will work exclusively on this project.

**ED PEDUTO** - (Project Manager/GCA Corp.): Directly responsible for GCA Corporation wastewater field sampling crews and will have day-to-day responsibility for monitoring sampling sites and equipment operation.

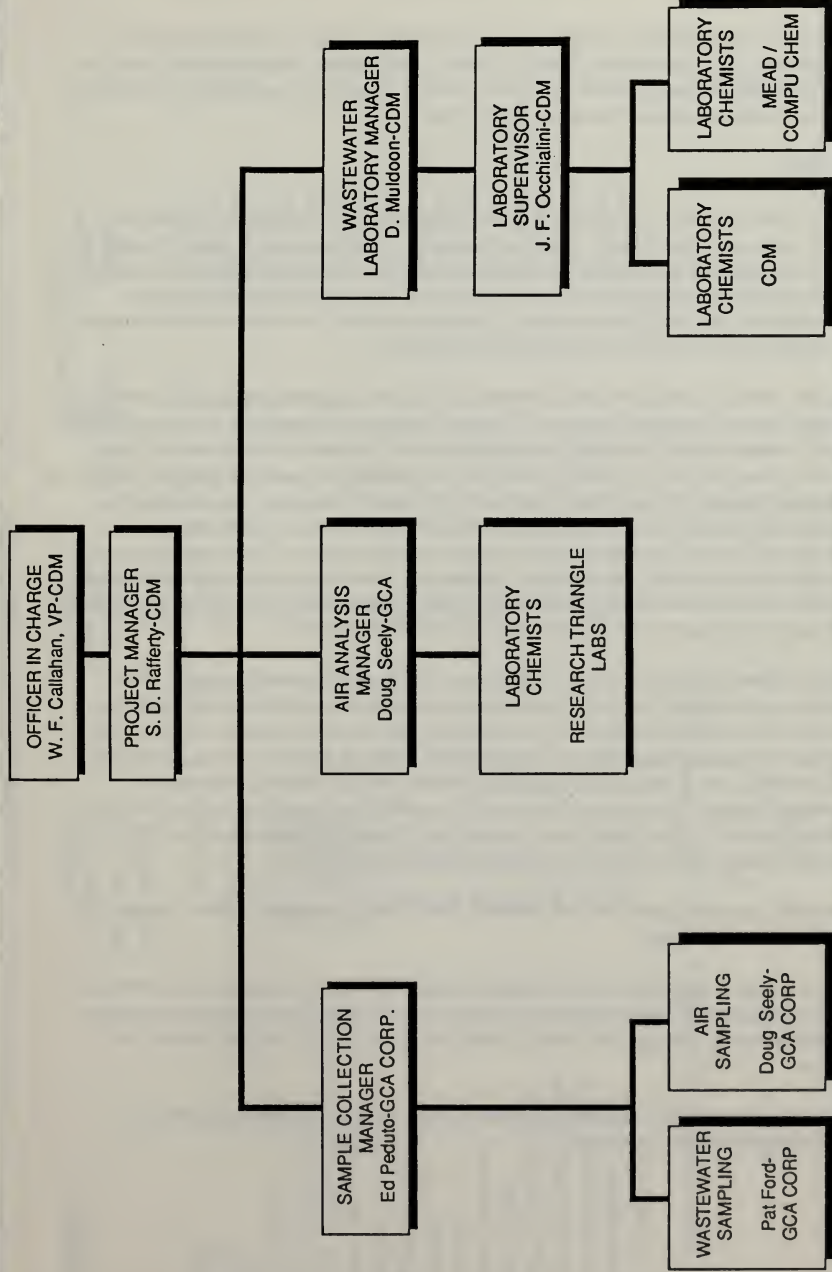
**SAMPLING TECHNICIANS** - GCA Corp. will employ between 8 and 12 technicians to perform the actual sampling.

**DOUG SEELY** - (Project Manager/GCA Corporation): Directly responsible for air sampling crews, forwarding of samples to Research Triangle Labs for analysis, and day-to-day monitoring of air sampling sites.

## 6.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

A major requirement of every sampling and analytical plan is to assure that all data collected be of known quality. The concept of data quality refers to the level of uncertainty associated with a data set. This section specifies a level of data quality for each parameter being investigated that is consistent with the purpose of the sampling event and the use of the data. It is important to note that the assurance of proper data quality begins with the writing of the project's sampling and analytical plan, the adherence to the specified sampling Standard Operating Procedure (SOPs), sample custody procedures, laboratory QA/QC procedures, and ends with the data validation process.





**MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY**

**FIGURE B-1  
SAMPLING PROGRAM - ORGANIZATION CHART**

Data quality requirements are specified using the precision, accuracy, representativeness, completeness, and comparability (PARCC) criteria. The required method detection limits for each parameter are also specified at this time. A brief discussion of each PARCC parameter as it relates to the sampling and analytical plan follows.

### Precision

The criterion of precision is a measure of the reproducibility of a given group of analyses under a given set of conditions. The overall precision of environmental monitoring data is the sum of the sampling precision and the analytical precision. Sampling precision is a function of the standard operating procedure used to collect the sample and the variability and/or homogeneity of the media being sampled. Analytical precision is a function of the procedure used, the analyst's technique, and instrument performance.

The best method to assess the overall precision of the entire sampling and analytical event is through the use of collocated samples. Collocated samples are independent samples collected in such a manner that they are equally representative of the parameter(s) of interest at a given point in space and time. The design of the MWRA sampling and analytical plan requires that the collocated samples be collected and processed by the same organization, thus providing precision information for the entire measurement system, including sample acquisition, homogeneity, handling, shipping, storage, preparation, and analysis. Collocated samples will be collected using side-by-side automatic samplers and simultaneous grab sampling techniques drawing from the same sampling location. Collocated samples will be included in the sampling and analytical program at a frequency of one per individual location.

Field replicated samples are the next best method of assessing the overall precision of the sampling and analytical program. Field replicated samples are samples obtained by dividing a sample into two representative portions immediately after the sample is taken. They provide precision information beginning with sample handling through shipping, storage, preparation, and analysis. Due to the inherent logistical problems associated with the collection of collocated samples, field replicated samples will provide the most precision information and will be included at a 5% frequency, or one per every twenty investigative samples. Field replicate data will be evaluated using criteria presented in Table B-7.

Laboratory (analytical) precision data obtained from laboratory replicates will be reported in the final laboratory report.

A split sample program using field replicated samples will also be coordinated with MWRA's existing influent and effluent sampling program. This split sample data will be evaluated for MWRA's internal use and will provide a source of inter-laboratory precision data for this project.

A split sample program using field replicated samples will also be coordinated with the Massachusetts DEQE, if requested.



## QUALITY ASSURANCE OBJECTIVES

Parameter	Accuracy (% recovery of lab matrix spike or lab control sample)	Precision Field Replicate RPD (1)	QC Sample Frequency	
			Blanks	Field Replicates
BOD5	Not Applicable	15	5%	5%
COD	85 - 115	15	5	5
TOC	85 - 115	15	5	5
Total Solids	Not Applicable	15	5	5
Total Suspended Solids	Not Applicable	15	5	5
Total Volatile Suspended Sol.	Not Applicable	15	5	5
Total Settleable Solids	Not Applicable	15	5	5
Chloride	80 - 120	15	5	5
Total Kjeldahl-N	80 - 120	20	5	5
Ammonia - N	80 - 120	20	5	5
Sulfide	85 - 115	15	5	5
Total Phosphorus	80 - 120	20	5	5
Oil & Grease	85 - 115	15	5	5
Priority Pollutant Metals	80 - 120	25	5	5
Priority Pollutant Volatiles	60 - 130	35	5	5
Additional HSL Volatiles	40 - 135	40	5	5
Semi-Volatiles	20 - 120	60	5	5
Pesticides/PCBs	45 - 125	40	5	5

1. Relative Percent Difference (RPD) is defined by the following equation:

$$RPD = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100$$

where  $D_1$  = First Sample Result  
and  $D_2$  = Second Sample Result (Duplicate)

A control limit of + the detection limit will be used for sample values less than three times the reported detection limit.

## Accuracy

Accuracy is a measurement of bias in a measurement system. Unlike precision, accuracy is difficult to measure for the entire measurement system. Sources of error that pertain to accuracy are the sampling process, field contamination, preservation, handling, sample matrix, calibration, and analysis. Accuracy will be monitored for this project by the use of field and laboratory blanks and matrix and surrogate spikes. Spike data will be reported as percent recovery.

The elimination of false positive and false negative values from the measurement system is the primary objective of the accuracy criterion, using both external program and laboratory QC. The potential for false positive values is monitored primarily by the use of field and laboratory blanks. The potential for false negative values is monitored through the use of spike recovery information.

The laboratory matrix spikes are used to document whether a sample exhibits any form of interference or matrix effect during the course of an analysis. A matrix effect is a phenomenon that occurs when the sample composition interferes with the analysis of the analyte(s) of interest. This can bias the sample result either in a positive or negative way, with the negative bias being the most common. Matrix spikes supply percent recovery information, which documents the magnitude of a matrix effect, and thus the amount of bias in the measurement system for that analyte. Percent recovery information can be used to adjust reported concentrations by the application of the appropriate correction factor or empirically to evaluate data with respect to some predetermined criteria. It is not recommended that sample values actually be adjusted for percent recovery unless a "worst case" scenario is being developed.

The frequency of inclusion and the types of QC samples used, as well as instrument calibration procedures, are documented in the laboratory's QA/QC plan. The plans are on file at each of the laboratories used. For wastewater, plans are at CDM Labs, One Center Plaza, Boston, MA; and CompuChem, 3308 Chapel Hill/Nelson Highway, P.O. Box 12652, Research Triangle Park, North Carolina, 27709. For air, the plans are at the lab at GCA Corp., 213 Burlington Road, Bedford, MA.

## Representativeness

The criterion of representativeness expresses the degree to which sample data represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with sampling program design.

Representativeness is best addressed by describing sampling techniques and the rationale used to select sampling locations. Sampling stations were primarily selected for this project so as to represent influent wastewater by headworks to ensure that no mass was lost in preliminary

treatment. The field locations for these samples have been verified by Mr. Stephen Rafferty.

Representativeness can be assured somewhat through the proper use of SOPs. Representativeness can be assessed to some degree by the use of collocated samples. By definition, collocated samples are collected so that they are equally representative of a given point in space and time. By evaluating the precision information obtained, an estimate of the variability at each location can be determined.

### Completeness

Completeness is a measure of the amount of valid data obtained from a measurement program compared to the amount that was expected to be obtained under normal conditions. Completeness is usually expressed as a percentage. Access to the sampling location, sampling problems, analysis problems and the data validation process can all contribute to missing data. An overall completeness goal, expressed as a percentage, is 75% of the samples to be collected, to assure that enough data of sufficient quality are obtained from the measurement system to fulfill the objective of this study.

Critical Data Points (CDPs) should be identified in every completeness statement. CDPs are sample locations or times that valid data must be obtained in order for the sampling event to be considered complete, regardless of whether the overall completeness objective has been met.

### Comparability

The criterion of comparability expresses the confidence with which one data set can be compared to another. The use of approved sampling and analytical SOPs and the reporting of analytical data in the appropriate units will satisfy this criterion. Seasonal variation attributed to the differences between the fall and spring sampling rounds will also be accounted for.

### Reported Levels of Detection

The detection limits that will be reported for the parameters of interest are listed in Table B-8. The detection limits for metals and VOAs have been set at lower levels than routine lab practice because of the impacts that even low levels of these compounds may have on the DIFP and RMFP. It should be noted that matrix effects or high concentrations of some sample constituents may cause detection limits to be raised during analysis.

## **7.0 SAMPLING PROCEDURES**

### **7.1 INTRODUCTION**

This section discusses the field sampling techniques, describes the field equipment, and lists the preservative chemicals needed. Reference to laboratory methods of analysis are included in Tables B-1 through Table B-5 in Section 2.6.

TABLE B-8

## REPORTED LEVELS OF DETECTION

CONVENTIONAL PARAMETERS

<u>Parameter</u>	(mg/l) <u>Detection Limit</u>
BOD 5-day	2
Total Solids	5
Total Suspended Solids	5
Total Volatile Suspended Solids	5
Settleable Solids	0.1
Chemical Oxygen Demand	10
Total Organic Carbon	0.1
Chloride	0.5
Total Kjeldahl Nitrogen	0.1
Ammonia	0.1
Sulfide	0.1
Oil and Grease	5
Cyanide	0.02

METALS ANALYSIS

<u>Element</u>	(ug/l) <u>Detection Limit</u>
Antimony	25
Arsenic	5
Beryllium	20
Cadmium	5
Chromium	5
Copper	5
Lead	5
Mercury	1
Nickel	5
Selenium	10
Silver	5
Thallium	10
Zinc	1
Boron	200
Molybdenum	50

TABLE B-8

**REPORTED LEVELS OF DETECTION**  
(Continued)

VOLATILE ORGANICS ANALYSIS

<u>Compound</u>	(ug/l) <u>Detection Limit</u>
<u>Priority Pollutants</u>	
Chloromethane	10
Bromomethane	10
Vinyl Chloride	10
Chloroethane	10
Methylene Chloride	5
Trichlorofluoromethane	10
1,1-Dichloroethylene	5
1,1-Dichloroethane	5
Trans-1,2-Dichloroethylene	5
Chloroform	5
1,2-Dichloroethane	5
1,1,1-Trichloroethane	5
Carbon Tetrachloride	5
Bromodichloromethane	5
1,2-Dichloropropane	5
Trans-1,3-Dichloropropene	5
Trichloroethylene	5
Dibromochloromethane	5
CIS-1,3-Dichloropropene	5
1,1,2-Trichloroethane	5
Benzene	5
2-Chloroethylvinylether	5
Bromoform	5
Tetrachloroethylene	5
1,1,2,2-Tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethylbenzene	5

TABLE B-8

**REPORTED LEVELS OF DETECTION  
(Continued)**

<u>Compound</u>	<u>(ug/l)</u> <u>Detection Limit</u>
<u>Additional HSL Compounds</u>	
Styrene	5
Total Xylenes	5
Carbon Disulfide	15
Vinyl Acetate	15
2-Butanone	15
Acetone	15
2-Hexanone	15
4-Methyl-2-Pentanone	15

HSL ACID BASE/NEUTRAL EXTRACTABLE COMPOUNDS

N-Nitrosodimethylamine	20
Phenol	20
Aniline	20
Bis(2-Chloroethyl)Ether	20
2-Chlorophenol	20
1,3-Dichlorobenzene	20
1,4-Dichlorobenzene	20
Benzyl Alcohol	20
1,2-Dichlorobenzene	20
2-Methylphenol	20
Bis(2-Chloroisopropyl)Ether	20
4-Methylphenol	20
N-Nitroso-Di-N-Propylamine	20
Hexachloroethane	20
Nitrobenzene	20
Isophorone	20
2-Nitrophenol	20
2,4-Dimethylphenol	20
Benzoic Acid	100
Bis(2-Chloroethoxy)Methane	20
2,4-Dichlorophenol	20
1,2,4-Trichlorobenzene	20
Naphthalene	20
4-Chloroaniline	20
Hexachlorobutadiene	20



TABLE B-8

**REPORTED LEVELS OF DETECTION**  
(Continued)

HSL ACID BASE/NEUTRAL EXTRACTABLE COMPOUNDS (Continued)

<u>Compound</u>	<u>(ug/l)</u> <u>Detection Limit</u>
P-Chloro-M-Cresol	20
2-Methylnaphthalene	20
Hexachlorocyclopentadiene	20
2,4,6-Trichlorophenol	20
2,4,5-Trichlorophenol	200
2-Chloronaphthalene	20
2-Nitroaniline	100
Dimethyl Phthalate	20
Acenaphthylene	20
3-Nitroaniline	100
Acenaphthene	20
2,4-Dinitrophenol	100
4-Nitrophenol	100
Dibenzofuran	20
2,4-Dinitrotoluene	20
2,6-Dinitrotoluene	20
Diethyl Phthalate	20
4-Chlorophenyl Phenyl Ether	20
Fluorene	20
4-Nitroaniline	100
4,6-Dinitro-2-Methylphenol	100
N-Nitrosodiphenylamine	20
4-Bromophenyl Phenyl Ether	20
Hexachlorobenzene	20
Phenanthrene	20
Anthracene	20
Di-N-Butyl Phthalate	20
Fluoranthene	20
Benzidine	100
Pyrene	20
Butylbenzyl Phthalate	20
3,3-Dichlorobenzidine	40

Note: The priority pollutant compounds 1,2-Diphenyl-Hydrazine,  
P-Chloro-M-Cresol, and 4,6-Dinitro-O-Cresol are not included  
on the Hazardous Waste Substance List and will not be reported.

TABLE B-8

REPORTED LEVELS OF DETECTION  
(Continued)

HSL ACID BASE/NEUTRAL EXTRACTABLE COMPOUNDS (Continued)

<u>Compound</u>	<u>(ug/l)</u> <u>Detection Limit</u>
Benzo(A)Anthracene	20
Bis(2-Ethylhexyl)Phthalate	20
Chrysene	20
Di-N-Octyl Phthalate	20
Benzo(B)Fluoranthene	20
Benzo(K)Fluoranthene	20
Benzo(A)Pyrene	20
Indeno(1,2,3-C,D)Pyrene	20
Dibenzo(A,H)Anthracene	20
Benzo(G,H,I)Perylene	20

PCB/PESTICIDE ANALYSIS

Aldrin	0.050
Alpha-BHC	0.050
Beta-BHC	0.050
Gamma-BHC	0.050
Delta-BHC	0.050
Technical Chlordane	0.50
4,4-DDT	0.10
4,4-DDE	0.10
4,4-DDD	0.10
Dieldrin	0.10
Endosulfan I	0.050
Endosulfan II	0.10
Endosulfan Sulfate	0.10
Endrin	0.10
Endrin Aldehyde	0.10
Endrin Ketone	0.10
Heptachlor	0.050
Heptachlor Epoxide	0.050
Methoxychlor	0.50
Arochlor 1016	0.50
Arochlor 1221	0.50
Arochlor 1232	0.50
Arochlor 1242	0.50
Arochlor 1248	0.50
Arochlor 1254	1.0
Arochlor 1260	1.0
Toxaphene	1.0



## 7.2 FIELD SAMPLING PROCEDURES

This section outlines the sampling and preservation technique checklist to be followed by the sampling crews for the automatic wastewater samples and the wastewater grab samples. Steps are in the order that they will be followed.

There are six sites to be sampled. The procedure for each site will include the procedures listed herein as necessary for that site. The sites and procedures are as follows:

- o Remote headworks: Columbus Park, Ward Street, and Chelsea Creek
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent and effluent grab samples
  - Tunnel shaft air samples
  - H<sub>2</sub>S air samples
- o Winthrop Terminal Headworks
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent grab samples
- o Deer Island Plant Effluent
  - Time composited grab samples from sedimentation basin prechlorination effluent channels
  - Sulfide, oil and grease, pH grab samples
  - VOA grab samples
- o Nut Island Influent
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent grab samples
  - H<sub>2</sub>S air samples
- o Nut Island Effluent
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent grab samples

There will be one time composite ISCO sampler maintained in standby status to be used in the event of a mechanical malfunction of any of the other automatic samples.

The daily composited samples will be collected from approximately mid-day to mid-day. Actual sample start and stop times will be staggered to account for the average travel time within the system.

Start times for the 24-hour composites will be as follows:

o	Ward Street	09:20 AM
o	Columbus park	11:05 AM
o	Chelsea Creek	11:35 AM
o	Winthrop Terminal	01:35 PM
o	Deer Island Influent	01:45 PM
o	Deer Island Effluent	03:00 PM
o	Nut Island Influent	01:45 PM
o	Nut Island Effluent	03:00 PM

#### Labeling Scheme

Sample bottles will be labeled with an identifying code. The code will be in the following format:

Client - Type - Location - Sample No.

The client is MWRA.

The type is WW for wastewater.

The location codes are given below for each of the 11 sample locations.

1. CPI = Columbus Park Headworks Influent
- CPE = Columbus Park Headworks Effluent
- WSI = Ward Street Headworks Influent

WSE	=	Ward Street Headworks Effluent
CCI	=	Chelsea Creek Headworks Influent
CCE	=	Chelsea Creek Headworks Effluent
WTI	=	Winthrop Terminal Influent
DII	=	Deer Island Influent
DIE	=	Deer Island Effluent
NII	=	Nut Island Influent
NIE	=	Nut Island Effluent

Each sample collected at a given location will be assigned a sequential number. Samples collected at the same time and location will be given the same number.

As an example of the labeling system, the first 24-hour composite sample collected at the Columbus Park influent would be labeled MWRA-WW-CPI-001.

Grab samples for VOA would receive an addition label of A, B, C or D. The label MWRA-WW-CPI-002A would identify the first (A) grab sample on day 2 from Columbus Park influent. This is because the grabs represent samples from that instant of time, whereas the composite represents a sample for a 24-hour period.

#### 7.2.1 PROCESSING OF THE FULL AUTOMATIC FLOW COMPOSITED SAMPLE

1. Sign in with the MWRA operator on duty with assigned responsibility.
2. Ask the MWRA operator what channels are scheduled for operation for the next 24 hours, record flow by hour for preceding 24 hours.
3. Turn off automatic sampler and record the time.
4. Open the sampler door.
5. Record any observed problems or questions about the condition of the sample or how the automatic sampler is running.
6. Examine sample bottle. Confirm that cap is clean.
7. Remove the sample bottle and put on the cap.
8. Label the bottle with the proper site identity code and sample description.
9. Visually check to see if the sampling tube is clogged, unclog, and/or replace if necessary.
10. Put the full sample bottle in the transportation cooler pack with ice.
11. Install a clean, empty sample bottle (rated for priority pollutants if required) in the sampler.
12. Close the door.
13. Turn on the automatic sampler and record the time.
14. Complete the chain of custody report.

#### 7.2.2 AUTOMATIC SAMPLER CALIBRATION (to be done a minimum of once every three days)

1. Open sampler and insert a sample bottle.
2. Activate the sampler.

3. Record the time for three samples to go into the bottle, record the flow rate over that same time period.
4. Turn off the sampler.
5. Pour the collected sample volume into a graduated cylinder.
6. Compare the total volume of the three collected samples to the average flow rate over that period to determine if the sample is correctly flow compositing; if necessary adjust pulse counter and repeat steps one through five.
7. Install the glass sample bottle.
8. Set sampler for 24-hour operation.
9. Turn on sampler.

### 7.2.3 pH, OIL AND GREASE, SULFIDE, CYANIDE GRAB SAMPLES

1. Calibrate the pH meter.
2. At the same influent channel location as the automatic sampler sample chamber, use the grab sample device with a collection container attached to take a sample at the water surface being sure to collect any floating material.
3. Test the pH directly from the collection container.
4. Record the pH on the collection form.
5. Pour a sufficient size sample into the 1000-ml glass oil and grease sample bottle to fill to the top. (Surface matter is allowed.)
6. Following the preservation techniques for oil and grease samples, preserve the sample.
7. Pour a sufficient size sample into the 125-ml plastic sulfide sample bottle to fill to the top.
8. Following the preservation techniques for sulfides, preserve the sample.
9. Label the grab sample bottles and fill out the sample custody forms.

### 7.2.4 WASTEWATER VOA SAMPLES

1. At the designated influent or effluent, use the grab sample device with a 1-liter amber glass bottle attached to take a sample just below the water surface.
2. Record the time to the nearest minute.
3. Select vial for the volatile organics sample, remove cap and incline vial at about a 45° angle. (Note: Caps with orange colored septums should be examined carefully before using. If the shiny Teflon side of the septum faces away from the sample, discard vial and select another.)
4. Slowly fill vial with a portion of the 1-liter amber bottle grab sample. Avoid bubbling and spilling while pouring.
5. Fill vial completely making sure a meniscus is present above the top. Use the cap or pipette to add the few last drops to produce the meniscus. The meniscus will help in sealing the vial without producing an air bubble.
6. Carefully close the vial with the Teflon-lined screw cap putting the cap perpendicularly on the vial. Avoid any contact with the underside of the septum. Make sure the cap is tightly screwed on.

7. Invert the vial and tap the screw cap to check for air bubbles. Any air bubbles would be seen rising to the top of the vial. If air bubbles are present, repeat steps 2 through 4 (throw vial away).
8. Make sure the vial is correctly labeled, place vial in styrofoam cup and place in the appropriate cooler after labeling the vials.
9. Repeat steps 1 through 6 for second sample.
10. Fill out sample sheets
11. Determine the total flow through all four channels, and using the detention time tables, figure out the detention time to the effluent channel sampling location.
12. This detention time added to the time from step 2 is when the VOA effluent grab sample should be taken.
13. At the effluent channel sampling location, use the grab sample device with a 1 liter amber bottle attached to take a sample just below the water surface
14. Repeat steps 2 to 11 above.

#### 7.2.5 VOA AIR SAMPLES (to be done by GCA)

1. Simultaneously with the collecting of the effluent wastewater VOA sample at the headworks, the air VOA sample at the tunnel shaft exit will be taken.
2. Check for air leaks in the stove pipe and plywood platform.
3. Use one hand to, determine which direction the air is going in the stove pipe connected to the tunnel shaft. Only proceed if air is exiting the stove pipe.
4. Take the VOA air sample. At the same time, measure the velocity of air leaving the stove pipe.
5. Fill out the appropriate sample forms.

#### 7.2.6 HYDROGEN SULFIDE AIR MONITORING

1.  $H_2S$  will be continuous monitoring, calibration will be bimonthly.
2. Check record.
3. If scheduled, calibrate meter.
  - a. Connect 25 ppm calibration gas cylinder to sensor/sample.
  - b. Adjust recorded speed from slow to high.
  - c. Open calibration gas cylinder, read recorder, adjust to 25 ppm as necessary.
4. Change the pen or the chart if required.
5. Fill out the appropriate sample forms.  
(These steps to be expanded once the procedures are better known)

### 7.3 DESCRIPTION OF THE SAMPLING EQUIPMENT

#### 7.3.1 COLLINS MODEL 42 AUTOMATIC SAMPLER

Three models of automatic samplers are utilized for the sampling program. The Collins Model 42 automatic sampler is priority pollutant rated, explosion-proof, and can accept a flow signal to automatically regulate the time between samples. It is semiportable and contains its own



refrigerator. Because of its explosion-proof quality, these samplers will be used at each of the remote headworks and at the Winthrop Terminal Headworks to sample the influent. A typical operating sequence is as follows:

- o Total flow signal in the range of 4 to 20 milliamps, enters sampler
- o Signal is converted to a pulse which represents the number of gallons that has passed through the facility at a given instant
- o The pulse is added to existing pulses on a pulse counter
- o When a predetermined number of pulses are reached, the compressor purges the sample line with air
- o A valve switches and the compressor draws 25 ml of sample into the 5 gallon glass bottle in a refrigerator in the sampler cabinet
- o Sequence of events are repeated until the sampler is turned off

#### 7.3.2 ISCO MODEL 2100 TIME COMPOSITE SAMPLER

The ISCO Model 2100 sampler is priority pollutant rated, contains 24 glass sample bottles, and is refrigerated by placing a bag of ice in its insulated housing. This portable sampler will automatically fill a sample bottle once per hour at locations where it is impractical to furnish a flow signal. These sampling locations include the Deer Island Treatment Plant effluent and Nut Island Treatment Plant effluent. The sampler will also be used as backup in the event of failure of the flow composited samplers. The sampler will run on rechargeable batteries and the 24 sample bottles will be flow composited in the field. The sampling sequence is very similar to that of the Collins sampler with a peristaltic pump replacing the air compressor.

#### 7.3.3 ISCO MODEL 1680 FLOW COMPOSITE SAMPLER

A modified priority pollutant rated ISCO Model 1680 sampler will sample from the remaining two locations; the Deer Island and Nut Island Treatment Plants' influent. The sampler is modified in that its ring of 28 bottles have been replaced by one 2-1/2 gallon glass container. A sample will flow directly from the Teflon tube to this container as timed by a flow signal. The sampling sequence is as described above for the Collins sampler.

#### 7.3.4 GRAB SAMPLING DEVICE

The grab sampling device is simply a mechanism that will guide a grab sampling container to a pre-specified location in the channel and hold it there against the current while the container fills.

## 7.4 FIELD NOTES

Careful documentation of both expected and unexpected events through field notes is as important as the actual collection of samples. Each sample location will have a loose leaf notebook that contains all the necessary instructions and forms required at that location. These forms are described in detail below.

### 7.4.1 COMPOSITE SAMPLE FORM

A form was used for samples that were flow composited in the field (Deer Island Treatment Plant influent and effluent). The following procedure was used:

1. Each hour, the instantaneous mgd is recorded by operators in the engine generator building control panel. Record the 24 hours on the composite sample form that corresponds to the automatic sampler sample bottles.
2. Divide the largest hourly instantaneous mgd into the volume of the smallest sample. This represents how many milliliters (ml) of sample is required per mgd.
3. For each hourly mgd, calculate the amount of sample that will be transferred to the composite sample container by using the value calculated in step 2.
4. Transfer the appropriate sample quantity to the composite sample container. Throw out any remaining sample contents from the individual 24 bottles.
5. Calculate the total volume in the composite sample container.

\*\*\* NOTE: A more accurate procedure to calculate the individual composite quantities is to average the instantaneous flow amounts shown on the flow recorder sheets in a period 1 hour prior to each time the sample was taken and substitute this number for the instantaneous flow amount mentioned in the above calculation. In fact, this is what the flow proportioning samplers do. The CDM Laboratory follows this method also. However, this method will not be used by the field crew because the other method is more simple and less likely to result in errors.

### 7.4.2 SAMPLING PROCEDURE CHECKLIST

Each day, the sampling crew will receive a work plan outline of the day's events. These outlines will refer to various sampling procedure checklists made from the sample procedures in Section 7.2. The outlines will also include any deviations from the procedures found in these checklists as well as special instructions required. After each item is completed, it should be checked off. At the end of the crew shift, the person in charge should also record the time of the shift and sign the checklist form.

## 8.0 SAMPLE CUSTODY PROCEDURES

### 8.1 CHAIN OF CUSTODY

The primary objective of the chain-of-custody procedures is to create an accurate written record that can be used to trace the possession of the sample from the moment of collection through its lab analysis.

Each sample is considered to be physical evidence from the Facility. The chain-of-custody procedures will provide documentation of the handling of each sample from the time it is collected until it is destroyed. This documentation will assure that each sample collected is of known and ascertainable quality.

A Chain-of-Custody Record will be filled out for each sample type at each sampling location to maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory which will analyze the sample (which will then continue the chain of custody within their laboratory records). Each time the samples are transferred to another custodian, signatures of both the person relinquishing the sample and the person receiving the sample, as well as the time and date, will be collected to document the transfer.

A sample Chain-of-Custody Record is shown in Figure B-2. Actual field forms will include two to three copies so that forms can be filled out simultaneously. The sampling team leader retains the original and his own copy and, one copy remains with the samples until they are received by the laboratory. If samples are split to different labs, a copy will go to each lab. Care must be taken that all copies are legible. If additional duplicate sheets are required, the person relinquishing the samples is responsible for filling out additional copies, or making reproductions. The original must be returned by the sampling team to CDM for MWRA project records; the sampling team will retain its copy.

The Chain-of-Custody Record will be placed in a ziplock bag and be included with each sample delivery. All samples will be hand-delivered to the CDM Boston laboratory. If a sample is to be analyzed by a subcontracted laboratory, that sample will be shipped via overnight delivery in compliance with chain-of-custody procedures. For the whole effluent toxicity testing program, Battelle will collect effluent samples from CDM's Boston laboratory in compliance with chain-of-custody procedures.

### 8.2 LABORATORY CUSTODY PROCEDURES FOR WASTEWATER SAMPLES

The CDM laboratory has designated a sample custodian for all wastewater samples. In addition, the laboratory has set aside a secured sample storage area. This is a clean, dry, isolated room with sufficient refrigerator space that is securely locked from the outside.

Samples will be handled by the minimum possible number of persons.

Incoming samples will be received by the custodian who will indicate receipt by signing the



**CDM**

PROJECT NAME:

[illegible]

SAMPLED BY (SIGN)

RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)
(1) _____ DATE/TIME ( / )	(2) _____ DATE/TIME ( / )	(3) _____ DATE/TIME ( / )	(4) _____ DATE/TIME ( / )
RECEIVED BY (SIGN)	RECEIVED BY (SIGN)	RECEIVED BY (SIGN)	RECEIVED BY (SIGN)
(1) _____ DATE/TIME ( / )	(2) _____ DATE/TIME ( / )	(3) _____ DATE/TIME ( / )	(4) _____ DATE/TIME ( / )

METHOD OF SHIPMENT	SHIPPED BY (SIGN)	RECEIVED FOR LABORATORY BY (SIGN)	DATE/TIME

LEGEND: Original: Return to Sample Traffic Control Center  
Copies: Ship with Samples

**MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY**

**FIGURE B-2**  
**CHAIN OF CUSTODY RECORD**

chain-of-custody record sheet accompanying the samples and retaining the sheet as a permanent record.

Immediately upon receipt, the custodian will place the samples in the sample room, which will be locked at all times except when samples are removed or replaced by the custodian. To the maximum extent possible, only the custodian will be permitted in the sample room.

The custodian will insure that all samples are properly stored, preserved and maintained.

Samples will be distributed to personnel who are to perform tests by the sample custodian under the direction of the laboratory supervisor.

The analyst will record information describing the sample, the procedures performed, and the results of the testing in the laboratory notebook or analytical worksheet. The notes will be dated, indicating who performed the tests, and will include any abnormalities that occurred during the testing procedure. The notes will be retained as a permanent record by the laboratory.

Only approved methods of laboratory analysis will be used.

Laboratory personnel are responsible for the care and custody of a sample once it is released to them.

The laboratory area is maintained as a secured area and is restricted to authorized personnel.

Once the sample analyses are completed, the unused portion of the sample, together with identifying labels and other documentation, is returned to the custodian. The returned sample is then retained in the custody room until permission to destroy the sample is received by the custodian.

Sample tags will be turned over to the laboratory supervisor and will be destroyed only upon his order. Samples will be destroyed only upon the order of the laboratory supervisor.

The sample custodian will acknowledge receipt of samples and initiate the chain-of-custody for samples which are delivered to the laboratory without applicable chain-of-custody documentation or with incomplete documentation. Sampling results for such samples will be reported with the following disclaimer:

Samples were received:

- ☐ without proper chain-of-custody
- ☐ deficient chain-of-custody

## 9.0 SAMPLE BOTTLE PREPARATION AND SAMPLE PRESERVATION

### 9.1 BOTTLE CLEANING PROCEDURES

Depending on the analyses to be performed and the nature of the samples being collected, the sample container must be treated according to specific procedures. For environmental samples, bottles should be washed as described in General Bottle Cleaning if: 1) they will be stored for later (not specified) usage, 2) they will be used for composite samples for a variety of routine analyses, 3) they will be used for routine analyses not requiring special preparation.

#### 9.1.1 GENERAL BOTTLE CLEANING

Bottle Material: plastic or glass

Bottle Size: Dependent upon determinations required

Cleaning Reagents:

1. Phosphate-free detergent
2. Distilled water

Procedure:

1. Rinse bottles with tap water.
2. Soak bottles in detergent solution for approximately thirty (30) minutes.
3. Scrub bottles with a brush.
4. Rinse bottles several times with tap water to remove the detergent.
5. Rinse bottles thoroughly, several times, with distilled water.

#### 9.1.2 BOTTLE CLEANING FOR METALS DETERMINATION

Bottle Material: Usually polypropylene

Bottle Size: Usually 500 ml

Cleaning Reagents:

1. Detergents
2. 1:1 Nitric acid
3. Distilled water

Procedure:

1. Follow general bottle cleaning procedure.
2. Add 1:1 nitric acid to bottles, cap, and shake briefly.
3. Allow bottles to stand for approximately 30 minutes, shaking them intermittently.
4. Pour acid from bottles and rinse them with tap water.
5. Rinse bottles thoroughly, several times, with distilled water.

### 9.1.3 BOTTLE CLEANING FOR OIL & GREASE DETERMINATIONS

Bottle Material: Glass with Teflon-lined cap

Bottle Size: One liter

#### Cleaning Reagents:

1. Acid solution of 1 + 1 Nitric acid
2. Detergent
3. Distilled water
4. Freon-113

#### Procedure:

1. Follow general bottle cleaning procedure.
2. Rinse bottles (excluding caps) with acid solution.
3. Pour acid from bottles and rinse them with tap water.
4. Rinse bottles thoroughly, several times, with distilled water.
5. Rinse bottles with Freon-113.

### 9.1.4 BOTTLE CLEANING FOR EXTRACTABLE ORGANICS

Bottle Material: Glass with Teflon-lined cap

Bottle Size: Usually one gallon

#### Cleaning Reagents:

1. Detergent
2. Chromic acid cleaning solution
3. Distilled water
4. Pesticide-grade hexane

#### Procedure:

1. Follow general bottle cleaning procedure.
2. Fill bottles with chromic acid cleaning solution and allow to stand for a minimum of 1/2 hour.
3. Pour chromic acid cleaning solution from bottles and rinse them thoroughly with tap water.
4. Rinse bottles several times with distilled water.
5. Rinse bottles and caps two times with pesticide-quality hexane.

### 9.1.5 BOTTLE CLEANING FOR HAZARDOUS SAMPLES

Bottle Material: Glass with Teflon-lined cap

Bottle Size: 40 ml for tank for high-hazard samples, up to 500 ml (wide mouth) for others

Cleaning Reagents:

1. Detergent
2. Distilled water
3. Reagent-grade methanol

Procedure:

1. Follow general bottle cleaning procedure.
2. Rinse bottle with methanol.
3. Bake for one hour at 300° F.

## 9.2 PRESERVATION TECHNIQUES

### 9.2.1 PRESERVATION TECHNIQUE FOR TOTAL METALS

Chemical Preservative: Ultrex concentrated HNO

Procedure:

1. Use bottle specifically cleaned for metal determinations.
2. Add 5 ml of Ultrex concentrated HNO per liter of sample. This should reduce the pH to less than 2.

### 9.2.2 PRESERVATION TECHNIQUE FOR OIL AND GREASE

Chemical Preservatives: Conc.  $H_2SO_4$  or HCL

Procedure:

1. Use bottle specifically cleaned for oil and grease determinations.
2. To avoid corrosion of oil-lined caps, preservative (Conc.  $H_2SO_4$ ) should not be added to empty bottles prior to sampling, but should be added to samples as soon as possible after collection.
3. Add 5 ml of concentrated  $H_2SO_4$  or HCL to one (1) liter of liquid sample. This should reduce the pH to less than 2.
4. Add 1 ml concentrated  $H_2SO_4$  per 80 g of solid sample.

### 9.2.3 PRESERVATION TECHNIQUE FOR CYANIDE

Chemical Preservative: NaOH

Procedure:

Add 2 ml of 10 N NaOH per liter of sample. This should increase the pH to greater than 12.

#### 9.2.4 PRESERVATION TECHNIQUE FOR PHENOLS

Chemical Preservative:  $\text{CuSO}_4$ ,  $\text{H}_2\text{SO}_4$  and  $\text{H}_3\text{PO}_4$

Procedure:

1. Add 10 ml of a 100 g/l  $\text{CuSO}_4$  solution per liter of sample in order to attain a concentration of 1 g/l  $\text{CuSO}_4$ , and acidify with  $\text{H}_2\text{SO}_4$  to a pH of less than 4.
2. Add a sufficient volume (usually 5 ml per liter of sample) of 1:9  $\text{H}_3\text{PO}_4$  to lower the pH of the sample to less than 4.

#### 9.2.5 $\text{H}_2\text{SO}_4$ PRESERVATION TECHNIQUE FOR COD AND ALL FORMS OF NITROGEN AND PHOSPHORUS

Chemical Preservative:  $\text{H}_2\text{SO}_4$

Procedure:

Add 2 ml of concentrated  $\text{H}_2\text{SO}_4$  per liter of sample. This should reduce the pH to less than 2.

#### 9.3 LABORATORY SAMPLE HOLD TIMES

The preservation requirements and hold times for samples are summarized in Table B-9.

#### References for Section 9

1. U.S. EPA, 1979. Methods for the Chemical analysis of water and wastes. March 1979. EPA-600/4-79-020.
2. A.P.H.A. 1975. Standard methods for the examination of water and wastewater. 14th ed.



TABLE B-9

## SAMPLE PRESERVATION AND HOLD TIMES

<u>Parameter</u>	<u>Preservative</u>	<u>Hold Time</u>
Ammonia	Cool, 4° L	28 days
BOD	11	48 hours
COD	Cool, 4° L H <sub>2</sub> SO <sub>4</sub> to pH < 2	28 days
Chloride	None required	28 days
Cyanide Total	NaOH to pH > 12	14 days
Kjeldahl Nitrogen	Cool, 4° C H <sub>2</sub> SO <sub>4</sub> to pH < 2	28 days
Trace Metals	HNO <sub>3</sub> to pH < 1	6 months
Oil and Grease	Cool, 4° L H <sub>2</sub> SO <sub>4</sub> to pH < 2	28 days
Volatile Organics	Cool, 4° L	14 days
Acid/Base - Neutral Extractables	Cool, 4° L	7 days: until extraction 30 days after extraction
Pesticide/PCB	Cool, 4° L	7 days: until extraction 30 days after extraction
Total Organic Carbon	Cool, 4° L, H <sub>2</sub> SO <sub>4</sub> to pH < 2	28 days
Total Phosphorus	Cool, 4° L, H <sub>2</sub> SO <sub>4</sub> to pH < 2	28 days
Total Suspended Solids	Cool, 4° L	7 days
Total Settleable Solids	Cool, 4° L	7 days

## 10.0 DATA VALIDATION

Validation of MWRA analytical data will be performed on two separate levels: Internal Laboratory Data Validation and External Program Data Validation.

### 10.1 INTERNAL LABORATORY DATA VALIDATION

All analytical data produced by the CDM Boston laboratory is validated prior to its release. This validation is conducted routinely as part of the laboratory's internal quality control program, using the guidelines established in the CDM Laboratory QA/QC Plan.

Performance goals and quality control evaluation procedures are documented individually for each analytical procedure used. This information is located within the individual CDM analytical procedures, specific to each parameter analyzed.

In general, all laboratory data is reviewed as it pertains to calibration, instrument performance, blank analysis, replicate analysis, and matrix and surrogate recovery. Also, the data is reviewed for the reasonableness of the analytical result (for example, suspended solids result greater than the total solids result of a sample), calculation and transcription errors. Of greatest importance is the elimination of false positive and false negative results. This validation process is complete when the sample analyst and laboratory supervisor sign off on the analytical report.

### 10.2 EXTERNAL PROGRAM DATA VALIDATION

The sampling and analytical plan for the MWRA project has its own QA/QC plan, which is independent of the laboratory's. This plan covers both the sampling and analytical component of the total measurement system. As such, the QA/QC information generated by following the plan will reflect both laboratory and field sampling performance.

This sampling and analytical plan specifies the inclusion of blind blanks and duplicate samples into the analytical system. These QC samples are prepared by the sampling team so that their true identity is unknown to laboratory personnel and are submitted for analysis at a frequency of 5 percent for blanks and 5 percent for duplicate samples.

These external QC samples provide the majority of the information used to review the data from a program perspective. The precision of the field duplicates is assessed and compared to the performance goals stated in Section 6.0 of this document. Field blank data and reported detection limits are also reviewed. Also, the laboratory QA/QC information reported with the analytical data is evaluated at this time.

The output of this program data validation is a usability report which attests to the suitability of the data or its intended use. Recommendations are included in this report which qualify specific pieces of data (if required) so that the information is not used incorrectly by project engineers. These recommendations are usually in the form of qualifying a reported



value as an estimate rather than an absolute value or the rejection of some reported values because of field blank contamination.

## **11.0 PERFORMANCE AND SYSTEM AUDIT**

Performance and systems audits are an essential part of every QA/QC plan. A performance audit independently collects measurement data using performance evaluation samples. A system audit consists of systematic, comprehensive review of the total data production process which includes on-site reviews of a field and laboratory's operational systems and physical facilities for sampling, calibration, and measurement protocols.

The audits conducted in support of the MWRA project serve three general purposes:

1. to determine whether a particular group has the capability to conduct the monitoring before the project is initiated;
2. to verify that the QA Project Plan and associated standard operating procedures are being implemented; and
3. to detect and define problems so that immediate corrective action can begin.

The CDM Boston laboratory participates in the U.S. EPA Water Supply (WS) and Water Pollution (WP) ongoing performance evaluations, which will serve as performance audits for this project.

Systems audits of the sampling and analytical portion of this project are the responsibility of the Quality Assurance Officer. The Quality Assurance Officer will present a schedule of when audits will be conducted and what each audit will cover. All audits will be conducted by individuals who are not directly involved in the measurement process and who are competent in the fields they are auditing.

A preliminary meeting will be conducted prior to initiating any system audit. During this meeting, the auditor will identify key personnel, define scope of audit, establish communication with field and laboratory staff, describe auditing plan and schedule, and set a date for completion along with a final briefing. The documentation required for audits includes a Quality Assurance Notice form and a Nonconformance Report.

## **12.0 CORRECTIVE ACTION PROGRAM**

### **12.1 CORRECTIVE ACTION PROGRAM**

The corrective action program in place during this phase of the MWRA project has the capability to discern errors or defects in the project implementation process.

The Quality Assurance Officer has the authority to make appropriate corrections and improvements as may be necessary in techniques and methods used by field and laboratory personnel.

Field and laboratory personnel are required to report to project management and the QA Officer any statistical data or other information that reflects a need for corrective action that should be implemented for a particular procedure or process.

Inspection steps taken during sampling, calibration and measurements should detect defects, malfunctions, or other problems which could jeopardize the sampling and analytical process and will trigger corrective actions to rectify the causes and stabilize the system.

## 13.0 SPRING SAMPLING SUPPLEMENT

### 13.1 INTRODUCTION

This section was a supplement to the QA/QC plan submitted in August of 1986 for the sampling of wastewater and air at the MWRA's Deer Island treatment plant, Nut Island treatment plant, and the headworks tributary to that system.

Unless otherwise noted, all procedures detailed in the August 1986 document will remain in effect for this element of the sampling program.

### 13.2 GOALS

The goal of the Spring Sampling Program was to collect and analyze representative samples from the MWRA system during the "wet weather" period. The wet weather period is defined as that period during which infiltration of groundwater has substantially altered the average daily flow conditions. The flows to the plants will be compiled for the two-month period prior to the start of sampling and for the period during the sampling.

Sampling will not start until the analysis of flows to the plant clearly indicate the influence of infiltration.

In addition to the types of samples and analysis included in the fall program, the spring program will include the collection of raw primary sludge at both treatment plants. The sludge will be analyzed for the presence of metals and PCBs. These analyses are for the RMFP's characterization of sludge.

The analysis of wastewater during the fall program resulted in the frequent reporting of values as being "below detection limits" for both metals analysis and for the Acid Base Neutral fraction. During the spring portion of the program the wastewater analysis is being modified, wherever possible, to lower wastewater detection limits.

### 13.3 SAMPLING SCHEDULE

Table B-10 outlines the proposed schedule for the spring program. The program is 14 days in length as originally proposed. For five of those days there will be sludge and VOC grab sample collection conducted at intervals over 24 hours.

TABLE B-10

## SPRING SAMPLING PROGRAM SCHEDULE

SPRING SAMPLING SCHEDULE	SAMPLE DAY AND LOCATION (note: fall program ended with day 30)														COMMENTS	M (C S)
	31	32	33	34	35	36	37	38	39	40	41	42	43	44		
CONVENTIONAL PARAMETERS																
BOD5	--DII, NII, WSI, CCI, CPI, MTI -----														No change from the original program as submitted in the Q/A Q/C	
TSS	--DII, NII, WSI, CCI, CPI, MTI -----															
SETTLABLE SOLIDS	--DII, NII, WSI, CCI, CPI, MTI -----															
CHLORIDES	--DII, NII, WSI, CCI, CPI, MTI -----														Detection limits and analytical procedures unchanged	
PH	--DII, NII, WSI, CCI, CPI, MTI -----															
PROCESS PARAMETERS																
COD	DII DII NII NII														No change from the original program as submitted in the Q/A Q/C	
VSS	DII DII NII NII															
TOTAL SOLIDS	DII DII NII NII															
TAN	DII DII NII NII														Detection limits and analytical procedures unchanged	
TOTAL P	DII DII NII NII															
AMMONIA NITROGEN	DII DII NII NII															
SULFIDES	DII DII NII NII															
METALS																
WASTEWATER TOTAL METALS	DII DII DII DII DII DII DII DII DII DII NII NII NII NII NII NII NII NII NII NII														Detection limits are being lowered, see attached list for detection limit goals. Lowered limits for outfall and RWFP needs. Soluble metals added for RWFP needs.	
WASTEWATER SOLUBLE METALS	DII DII DII DII DII NII NII NII NII NII															
SLUDGE TOTAL METALS	DII DII DII DII DII NII NII NII NII NII														Sludge samples requested for RWFP needs. Samples to be collected in accordance with protocol as outlined in the local limits study. Analysis to conventional detection limits. Soluble is a non-standard proce	
SLUDGE SOLUBLE METALS	DII DII DII DII DII NII NII NII NII NII															
ACID-BASE/NEUTRAL, PESTICIDES AND PCBs in WASTEWATER																
	DII DII DII NII NII NII														Program similar to original Q/A Q/C.	
PCBs in SLUDGE																
	DII DII DII NII NII NII														Added per RWFP request. Analysis and limits as per original Q/A Q/C	
VOLATILE ORGANICS																
PP & HSL VOCE with cesaron twice/day	DII DII DII DIE DIE DIE DIECIECIEC NII NII NII														At request of air emission evaluation samples are being both prechlorination (DIE) and postchlorination (DIEC). Sample days reduced from 5 to 3.	
ORGANIC SPECIATION	DII DII NII NII														Speciation analysis by capillary GC/MS for organic groups including Hydrocarbons, Amines, Aldehydes, Su including flame ionization deta	

### 13.4 SAMPLING LOCATIONS

#### 13.4.1 SLUDGE

The sludge sample from Deer Island will be collected after thickening and prior to digestion. The samples will be collected from sampling taps located in the pump rooms in the basement of the Sludge Thickener Building. Sampling will be rotated among the thickeners in service. A sample will be taken every four hours.

The sludge sample from Nut Island will be collected from sampling taps at one of two pumps which are operated in each of the three pump houses. Samples will be taken first at Pump House No. 1, then 3 hours later at Pump House No. 2, then four hours later back at Pump House No. 1 etc. These are the same locations as originally defined and utilized by Black and Veatch during the MWRA's Local Limits study.

#### 13.4.2 WASTEWATER

All influent wastewater sampling locations remain the same as used in the fall program.

VOC effluent samples at Deer Island will be taken from two locations. Prechlorination VOC samples will be taken from the effluent end of the primary sedimentation basins, prior to passing over the weir into the effluent channel. These samples will be tagged as DIE. Postchlorination VOC samples will be collected from the sampling tap located in the process water building downstream of the point where the effluent channel discharges into the outfall pipeline. These samples will be tagged as DIEC. The purpose of sampling pre- and post-chlorination is to evaluate the release of VOCs during agitation occurring as the effluent drops from the effluent channel into the outfall pipeline.

### 13.5 SAMPLE COLLECTION AND ANALYTICAL PROCEDURE

#### 13.5.1 WASTEWATER METALS

Table B-2 of the QA/QC, "Sample collection and analytical procedures by metal," is being modified for wastewater sample collection and analysis in accordance with Table B-10. (The detection limits for sludge samples will remain at the limits established in Table B-2) This table outlines the goals for detection limits that are being set for the Spring Sampling Program. These detection limit goals will be applied to both total metals and soluble metals for wastewater analysis. Table B-11 provides a listing of the fall detection limit goals, reference analytical procedure detection limits (the reference procedure is for clean water without matrix interference), and outlines the goals for the spring. In order to reach the established goal, the lab procedure is being modified to concentrate a larger volume of wastewater sample for analysis. Accordingly, the sample collection is being modified at the plant's influents to increase the sample volume collected.

Table B-11

**MWRA SPRING 1987 SAMPLING PROGRAM  
METAL ANALYSIS DETECTION LIMITS INFORMATION**

METAL	Fall 87 Prev. Det. Limit	Reference Standard <u>Det. Limit</u>		Detection Limit Goal For Spring
	<u>ppb</u>	Graphite Furnace(1)	Inductively Coupled(2)	
Antimony	25.00			25.00
Arsenic	10.00	1.00	53.00	1.00
Arsenic IV	N/A	N/A	N/A	N/A
Arsenic III	N/A	N/A	N/A	N/A
Beryllium	20.00	0.20	0.30	0.20
Boron	200.00			10.00
Cadmium	5.00	0.10	4.00	0.50
Hexavalent Chromium	20.00	5.00	10.00	5.00
Trivalent Chromium	N/A	5.00		5.00
Copper	50.00	1.00	6.00	1.00
Lead	50.00	1.00	42.00	1.00
Mercury	1.00	0.20	1.00	0.20
Molybdenum	50.00	1.00		5.00
Nickel	20.00	1.00	15.00	1.00
Selenium	10.00	2.00	75.00	5.00
Silver	5.00	0.20	7.00	1.00
Zinc	2.00	0.05	2.00	2.00
Cyanide	20.00	20.00		5.00

(1) Methods for the Chemical Analysis of Water and Wastes EPA - 600/4-79-020.

(2) Inductively coupled - plasma emission spectroscopy prominent lines: EPA - 600/4-79-017.



### 13.5.2 SLUDGE METALS

The analysis of metals in the sludge will be done in accordance with the procedure outlined in Table B-2 of the QA/QC plan.

Past sampling and analysis during the local limits study has shown that the detection limits for metals established during the fall program are adequate for the detection of metals in sludge from the two plants. Sludge will not be analyzed to the detection limit goals established for spring wastewater. The analysis of sludge for total metals will be reported on a dry weight basis.

In addition to analyzing sludge for total metals, the sludge will also, if possible, be analyzed for soluble metals. The methodology for the separation of the soluble portion of the sludge sample is not a defined procedure and the ability to separate the solids portion of the sludge from the soluble portion will be dependent upon the quality of the sampled sludge. The following procedure will be utilized: the sample will be centrifuged to separate the major portion of the solid fraction; the decant portion will then be filtered through a 0.45 micron screen; and the filtered portion will be analyzed for soluble metals. This procedure assumes that the sludge is collected at between 3 and 7 percent solids in the field.

### 13.5.3 WASTEWATER VOLATILE ORGANIC COMPOUNDS (VOCs)

The VOCs will be sampled and analyzed as stated in Table B-3 of the QA/QC. During the Fall Sampling Program, one quarter of the samples were searched for the presence of other volatile compounds not listed on the priority pollutant list, or the hazardous substance list. A total of six additional compounds were identified through that search process. At the remote headworks air sampling for VOCs was conducted. Compounds were detected in the air analysis that were not detected in the wastewater analysis. These air compounds were generally detected in low concentrations in the air and fell into two categories; fluorodated hydrocarbons and gasoline components. During the spring sampling, additional analysis consisting of capillary GCMS and flame ionization detection of the wastewater grab samples for two days has been added to quantify the organic fractions of the wastewater that are likely to contain both the fluorodated hydrocarbons and the highly-volatile gasoline components.

### 13.5.4 ACID/BASE/NEUTRAL COMPOUNDS AND PCB/PESTICIDES

The collection and analysis for the Acid/Base/Neutral Compounds and the PCB/pesticides in wastewater will be essentially the same as those performed for the fall program. The analysis will be conducted by CompuChem, the same lab used for the analysis in the fall. It should be noted that the detection goals are equal to the limits utilized in the fall. There was an internal request to lower the detection limits. However, we were unable to locate labs that, as part of standard analysis, could achieve lower detection limits on the compounds from a wastewater sample.

### 13.6 SAMPLING PROGRAM INITIATION

The Spring Sampling Program will begin once there is a clear indication that groundwater infiltration is influencing the average daily flows in the system.

At Deer Island it is difficult to measure the influence of infiltration from the daily flow records. The facility has a limited number of operational pumps, and any flows in excess of the pumping capacity are "choked" or held upstream of the remote headworks. A review of the flow records and summary of hours choked since January 1, 1987, clearly indicates the difficulty in establishing a clear trend.

At Nut Island it is much easier to evaluate the impact of groundwater infiltration upon the system. The relationship between flow and rain events (and snow events converted to inches of rain) at Nut Island is portrayed in Figure B-3. The Figure provides flow information at Nut Island since January 1, 1987. Once the average daily flow, in the absence of rain events, rises above the base level of 160 MGSD, and remains above that level, the Spring Sampling program should begin.

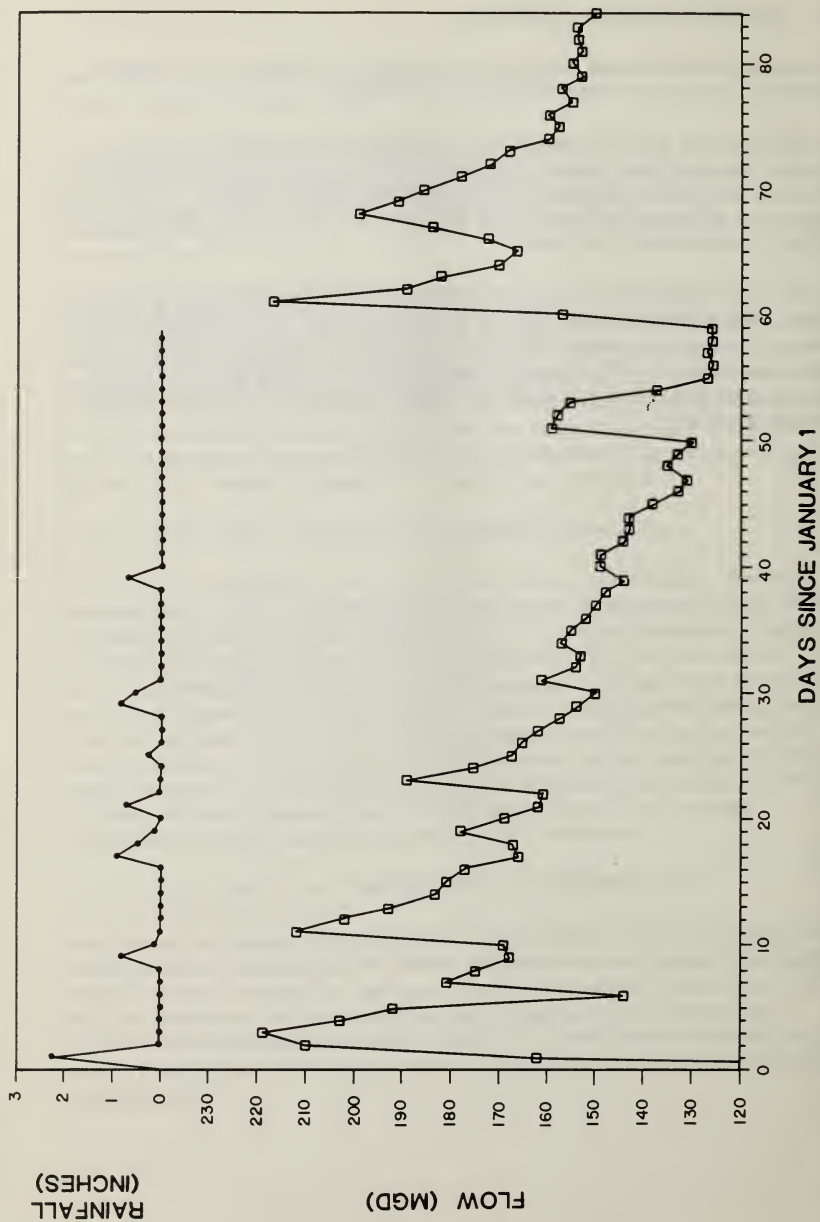


FIGURE B-3  
NUT ISLAND WASTEWATER FLOWS  
AND RAINFALL-SPRING 1987



## Appendix C



**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix C  
Unit Process Description**

SECONDARY TREATMENT FACILITIES PLAN  
VOLUME III  
APPENDIX C  
UNIT PROCESS DESCRIPTION

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## Appendix C

### Unit Process Description

#### 1.0 PRELIMINARY TREATMENT

##### 1.1 SCREENING

The coarse screening operation is frequently the first operation in a wastewater treatment plant. The screening operation removes from the wastewater the solids and trash that may impact the performance of downstream treatment equipment and processes. Coarse screens also prevent large objects such as logs from damaging downstream equipment. The coarse screens to be considered for use for this project are bar racks and bar screens. The bar screens would consist of bars having a 3/4-inch openings and a raking or cleaning mechanism. The bar racks, also cleaned mechanically, would have 3-inch openings.

The types of screens investigated for use as either a bar rack or bar screen are described below:

###### 1.1.1 CATENARY SCREEN

This screen's cleaning mechanism consists of tooth rakes attached to a chain forming a catenary loop in front of the screen. The catenary screen eliminates submerged sprockets, shafts, or bearings, thereby minimizing maintenance.

###### 1.1.2 CLIMBER SCREEN

This screen also provides a front clean, front return mechanism with the motion of the rake following a direct up-down path similar to that of a man using a rake. This system does not have submerged moving parts. Also, when the system is not raking, there is no equipment below the water surface other than the screen bars.

##### 1.2 GRIT REMOVAL

In wastewater, the term grit describes those particles having settling velocities much greater than the putrescible organic solids. Examples of solids that fall under the grit classification are gravel, sand, coffee grounds, and seeds. Grit should be removed early in the treatment process scheme to prevent clogging of pipes and channels and to protect mechanical equipment from unusual wear and abrasion.

The grit removal options studied during this screening report are given below:

### 1.2.1 HORIZONTAL FLOW CHANNEL

The horizontal flow grit chamber is designed to maintain a constant velocity through the tank over a range of flows. Gates are used to control flow to each unit. A velocity of 1 fps will keep most of the organic material present in the wastewater suspended, and allow the heavier grit particles to settle. The grit is usually collected by a chain and flight mechanism, a screw conveyor, a pumping system, or a combination of these systems. In some instances an overhead clamshell bucket is used.

### 1.2.2 AERATED GRIT CHAMBER

An aerated grit chamber utilizes diffused air to induce a spiral velocity over a wide range of flow conditions. The air is supplied along one side of the chamber, generating a rolling motion in the water. The amount of air supplied determines the velocity of the roll, which controls the quantity of grit and organic material that is settled. The settled grit is swept along a sloped channel bottom by the rolling action to a hopper where it is collected. The grit may be collected by a chain and flight mechanism, a screw conveyor, a pumping system, or a combination of these systems. An overhead clamshell bucket system may also be used.

### 1.2.3 CENTRIFUGAL GRIT CHAMBER

These circular grit chambers use the combined action of centrifugal force and gravity to move incoming grit particles to the center of the chamber floor. The settled grit particles are collected in a central hopper by a screw conveyor or a pumping system. A circulating paddle may be used to impart the circular or vortex flow pattern during low flows, and to increase the particle velocity along the floor of the chamber, allowing resuspension of the lighter organic material. The centrifugal force is the result of an induced vortex water pattern created by the circular shape of the chamber.

### 1.2.4 CYCLONE PRIMARY SLUDGE DEGRITTING

The grit removal options discussed previously would be placed in the treatment process train prior to primary sedimentation. This alternative, primary sludge degritting, would remove grit from the wastewater as part of the primary sedimentation process. Dilute primary sludge containing grit would be passed through cyclone degritters to separate the grit from the primary sludge solids. The primary sludge must be fed to the cyclone degritters at a low solids concentration of 1/2 percent. The degrittied primary sludge stream is commonly thickened prior to subsequent sludge processing.

## 1.3 PREAERATION

Preaeration of raw wastewater before primary sedimentation is practiced to enhance BOD and suspended solids removal in the primary sedimentation tanks. The effectiveness of the preaeration process to increase BOD and suspended solids removal is directly dependent on the detention time. The air supplied to the process keeps materials in suspension and evenly distributed, and also freshens the wastewater.



## Appendix C Unit Process Description

### 2.0 PRIMARY TREATMENT

#### 2.1 PRIMARY CLARIFIER, RECTANGULAR

Primary clarification involves a relatively long period of quiescence in a basin where most of the settleable solids in a pretreated wastewater fall out of suspension by gravity. The solids are mechanically transported along the bottom of the tank by a scraper mechanism and pumped as a sludge underflow.

Scum floats to the surface and is usually collected at the effluent end of rectangular tanks by the flights returning at the liquid surface. The scum is then scraped manually up an inclined apron, or it can be removed hydraulically or mechanically.

#### 2.2 PRIMARY CLARIFIER, CIRCULAR

The circular clarifier is equipped with an influent feed, well located in the center, which distributes the influent radially, and a peripheral weir overflow system that carries the effluent. A rotating mechanical scraper conveys sludge to a center hopper. Floating scum is trapped inside a peripheral scum baffle and scraped up an inclined apron into a scum discharge box.

#### 2.3 PRIMARY CLARIFIER WITH CHEMICAL ADDITION

In this process, salts of calcium, iron, or aluminum are added to pretreated wastewater. Precipitated phosphorus, as well as considerable BOD and suspended solids, are removed from the system as primary sludge. The floc formed by the chemical increases suspended solids and associated BOD removals over those expected without chemicals and at the same overflow rate. Mixing and flocculation are needed for this process, and the primary basins must be modified for this.

#### 2.4 TRAY CLARIFIERS

Tray clarifier units are similar to conventional rectangular clarifiers with the following differences. The units are stacked with wastewater entering the lower unit and traveling to the upper. No pumps are needed to lift the flow. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper and to further sludge processing.

#### 2.5 STACKED CLARIFIERS

Stacked clarifier units are similar to conventional rectangular units except that two clarifier units are constructed over one another. This saves approximately 40 percent of the total area

required for conventional rectangular clarifiers. Stacked clarifiers, unlike the tray-type units, have separate wastewater influent distribution and effluent collection facilities. Each stacked clarifier can be operated independently of the other. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper for further sludge processing.

## 2.6 INCLINED TUBE SETTLERS

Inclined tube settlers are shallow settling devices consisting of bundles of small plastic tubes. The tubes are used to enhance the settling characteristics of sedimentation tanks and to decrease detention times. Tube shape, hydraulic radii, inclination, and length of the units vary according to the particular manufacturer. Typical practice is to insert modules of tube settlers in sedimentation tanks (either rectangular or circular) to sufficient depth. Flow within the clarifier passes upward through the tube and exits. The solids move downward counter-currently and out of the tube modules to the tank bottom by means of gravity.

## Appendix C

### Unit Process Description

### 3.0 SECONDARY TREATMENT

#### 3.1 ACTIVATED SLUDGE, AIR

Activated sludge is a continuous flow biological treatment process characterized by a suspension of aerobic microorganisms, maintained in a relatively homogeneous state by the mixing and turbulence induced by aeration. The microorganisms oxidize soluble and colloidal organics to  $\text{CO}_2$  and  $\text{H}_2\text{O}$  in the presence of molecular oxygen. During the oxidation process, a certain amount of the organic material is synthesized into new microorganisms. Oxygen is required in the process to support the oxidation and synthesis reactions. Volatile compounds are driven off to varying extents in the aeration process. The process is generally, but not always, preceded by primary sedimentation. The mixture of microorganisms and wastewater formed in the aeration basins, called mixed liquor or activated sludge, is transferred to clarifiers following aeration for liquid-solids separation. The major portion of the microorganisms settling out in the clarifiers is recycled to the aeration basins to be mixed with incoming wastewater, while the excess, which constitutes the waste sludge, is sent to the sludge handling facilities. The rate and concentration of activated sludge returned to the aeration basins determine the mixed liquor suspended solids (MLSS) level developed and maintained in the basins.

All activated sludge processes will be evaluated with the use of selectors. The selector is an anaerobic (or aerobic) zone of initial contact between biomass and influent to provide a competitive advantage for desired microorganisms. These microorganisms assimilate most of readily available organics so that organisms that have good settling characteristics dominate. This enhances non-bulking conditions in secondary clarifiers. Bulking sludge is a major problem at some municipal treatment plants.

#### 3.2 ACTIVATED SLUDGE, OXYGEN

Oxygen activated sludge, like other activated sludge processes, uses suspended microorganisms to remove organics contained in domestic wastewater. The organisms are fed to and contacted with wastewater in continuous flow-through treatment tanks. Pure oxygen, which is normally provided by onsite generation equipment, is diffused into the aeration tanks by mechanical mixing equipment.

Pure oxygen systems are generally enclosed and operated under a slight pressure in an oxygen rich atmosphere. Consequently, the system has a higher dissolved oxygen concentration.

### 3.3 BURNS-McDONNELL TREATMENT SYSTEM (BMTS)

BMTS is an activated sludge system in which the aeration tank is a racetrack shaped oxidation ditch and the clarifier is suspended inside the aeration tank. Most of the mixed liquor flows beneath the clarifier, while part of it flows upward into the clarifier. In the clarifier, solids separate from the liquor and fall back into the mixed liquor. The clarified effluent flows into orifice pipes submerged beneath the water surface.

### 3.4 POWDERED ACTIVATED CARBON

Powdered activated carbon is used in activated sludge systems to adsorb soluble organic materials and to aid in the clarification process. Powdered carbon is fed to the aeration tanks. The spent carbon is removed within the sludge and is disposed of or regenerated.

### 3.5 DEEP SHAFT

The deep shaft system is an activated sludge process that employs a vertical underground shaft to provide highly efficient oxygen transfer for the biodegradation of wastewater. Biological solids can be separated using either subsequent flotation or sedimentation.

According to the manufacturer, Deep Shaft Technology Inc., the deep shaft bioreactors may vary in depth (300-800 ft) and in diameter (1.5 - 30 ft). A shaft is divided into "downflow" and "riser" sections, and the latter is surmounted by a gas-disengagement tank where gross bubbles of dispersed nitrogen, residual oxygen, and carbon dioxide are released. A portion of the flow from the gas-disengagement tank is fed to a solids separation system, while the remainder is recycled through the shaft.

### 3.6 SEQUENCING BATCH REACTOR (SBR)

The SBR unit is a method of wastewater treatment that uses the same basin for both biological degradation and solids-liquid separation. By using a single basin design and operation, the need for separate clarifier units and equipment normally associated with such structures (i.e. sludge return lines scrapers) is eliminated.

The basin is operated with an aeration sequence followed by a non-aeration sequence. These two sequences together constitute a cycle. Near the end of the non-aeration sequence, after solid-liquid separation has taken place, effluent, as surface liquor, is removed from the basin until the designated operating bottom water level is reached. The cycle is then repeated. The process operates in the batch mode.

### 3.7 ROTATING BIOLOGICAL CONTACTORS (RBCS)

RBCs are biological-disc units that consist of a shaft of rotating circular plates immersed approximately 40 percent in a contour bottom tank. The discs are spaced so that during

submergence, wastewater can enter between the surfaces. When rotated out of the tank, air enters the voids while the liquid trickles out over the fixed films of biological growth attached to the media. Excess microbial solids on the media are stripped off by rotational shear forces and the stripped solids are maintained in suspension by the mixing action of the rotating media. Multiple staging of RBCs increase treatment efficiency. The process is similar to trickling filters in that treatment is provided via biological fixed-film attached growth.

### 3.8 TRICKLING FILTER, PLASTIC MEDIA

The process consists of a fixed bed of plastic media over which wastewater is applied for aerobic biological treatment. Zoogea biological slimes form on the media, which assimilate and oxidize substances in the wastewater. The bed is dosed from the top, and the treated wastewater is collected by an underdrain system.

The organic material present in the wastewater is degraded by a population of microorganisms attached to the filter media. As the microorganisms grow, the thickness of the slime layer increases. Periodically, the liquid will wash some slime off the media, and a new slime layer will start to grow. This phenomenon of losing the slime layer is called sloughing and is primarily a function of the organic and hydraulic loadings on the filter. Filter effluent recirculation is vital with plastic media trickling filters to ensure proper wetting of the media and to promote effective sloughing control compatible with the high organic loadings employed.

### 3.9 BIOLOGICAL FILTRATION

Biological filtration is a filtering process that relies on suspended aerobic growth on a fixed granular media to reduce organic levels. In the up-flow mode, air injection provides the fixed culture with the necessary oxygen required for the level of BOD removal necessary. The granular media forming the biological growth area also acts in the traditional role, filtering out suspended solids.

One downflow process, patented by Infilco-Degremont, Inc., is known as the Biodrof process. The process is a dry bed downflow filtration process in which the filter and biological growth media are never submerged. The influent is metered onto the media through a series of launders equipped with orifices. Air is drawn into the filter media concurrently by a blower-induced vacuum applied to the media through the underdrain at the level necessary for the biological activity required.

### 3.10 COUPLED SYSTEM

The coupled system consists of two unit processes (fixed film and activated sludge). The processes that will be evaluated for the MWRA project are the trickling filter and aeration units. The settled solids from the final clarifier are recycled to the head of the aeration basin and mixed with the flow from the fixed film process. A portion of these solids are wasted in order to maintain the desired concentration of MLSS in the aeration basin. The



potential advantages offered by the coupled system are (1) lower energy usage since a large fraction of the BOD can be removed in the fixed film process; (2) better settling solids from the aeration basin (depending on the operational mode selected) as compared to those in the conventional activated sludge process; and (3) more uniform load on the activated sludge system since the fixed film process reduces peak BOD load.

### 3.11 PULSED BED FILTRATION

In conventional single-medium sand filters, most of the solids are removed at or near the surface of the sand bed forming a layer of solids. As a result, head loss increases rapidly, filter runs are short, and most of the removal capacity of the filter bed is not utilized. In the pulsed bed filter, intermittent air pulsing of the filter bed is used to loosen and mix the solids retained in the surface layers of the filter, moving this material deeper into the sand bed. The pulse action and the attendant redistribution of solids within the bed decrease the rate of head loss buildup, allowing longer filter runs. Two stage filtration with polymer addition is required to achieve suspended solids removal equivalent to secondary treatment. However, BOD<sub>5</sub> removals equivalent to secondary treatment will not be achieved.

### 3.12 PHYSICAL-CHEMICAL TREATMENT

Independent physical-chemical treatment utilizes physical-chemical unit processes rather than biological treatment to provide secondary treatment.

A typical process train is as follows:

1. Chemical Mix -- Lime is added to the raw wastewater to reduce the level of suspended organic solids.
2. Sludge Blanket Clarifier -- Flocculation and sedimentation of particles
3. Filtration -- Suspended solids and BOD removal
4. Activated Carbon -- Adsorbance of soluble organic materials

### 3.13 SECONDARY CLARIFIERS, RECTANGULAR

The design of secondary clarifiers is similar to primary clarifiers except that the volume and hydraulic nature of the flocculent solids in the mixed liquor must be considered during the design of activated sludge clarifiers and in the sizing of sludge pumps.

### 3.14 SECONDARY CLARIFIERS, CIRCULAR

The design of secondary clarifiers is also similar to primary clarifiers except that the volume and hydraulic nature of flocculent solids in the mixed liquor must be considered during the design of activated sludge clarifiers and in the sizing of sludge pumps.

Two types of units exist: (1) the center feed, and (2) the rim feed. Both utilize a revolving mechanism to transport and remove the sludge from the bottom of the clarifier. Circular clarifiers are made with effluent overflow weirs located near the center or near the perimeter of the tank.

### 3.15 SECONDARY CLARIFICATION (HIGH RATE), FOLLOWED BY FILTRATION OR SCREENING

The clarifiers in a high rate/filtration process are designed at an overflow rate of 800 gal/day/ft<sup>2</sup> compared to a conventional system with an overflow rate of 450 gal/day/ft<sup>2</sup>. Under one option, secondary clarification is followed by a filtration process. A typical multimedia filter (55 percent coal, 30 percent sand, 15 percent garnet) loaded at 5 gpm/ft<sup>2</sup> would produce an effluent of less than 10 mg/L. Under a second option secondary clarifiers would be followed by microscreens. Microscreening is a physical straining process normally used to remove suspended solids from secondary effluents for polishing purposes. A typical unit consists of a motor driven rotating drum, covered with a fine screen. The unit is usually mounted horizontally in a rectangular channel. The wastewater enters the drum through one end and passes out through the screen, with the suspended solids being retained on the inner surface of the screen. Pressure jets of plant effluent are directed down onto the screen to remove the deposited solids from the inside of the drum. The wash water must be recycled upstream to the point where the main portion of the solids are removed from the wastewater being treated. Biological growths on the microscreen are controlled by periodic treatment with a chlorine solution. In some cases, placing ultraviolet lights above the screen medium has been effective in controlling growths.

### 3.16 TRAY CLARIFIERS

Tray clarifier units are similar to conventional rectangular clarifiers with the following differences. The units are stacked with wastewater entering the lower unit and traveling to the upper. No pumps are needed to lift the flow. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper and to further sludge processing.

### 3.17 STACKED CLARIFIERS

Stacked clarifier units are similar to conventional rectangular units except that two clarifier units are constructed over one another. This saves approximately 40 percent of the total area required for conventional rectangular clarifiers. Stacked clarifiers, unlike the tray-type units, have separate wastewater influent distribution and effluent collection facilities. Each stacked clarifier can be operated independently of the other. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper for further sludge processing.

### 3.18 ROTARY SCREEN

A rotary screen is a horizontal or rotating drum covered with a plastic or stainless steel screen of uniformly sized openings, installed and partially submerged in a chamber. The chamber is designed to permit the entry of wastewater to the interior of the drum and



collection of screened wastewater from the exterior side of the drum. With each revolution, the solids are flushed by sprays from the exposed screen. Rotary screens have been used for further treatment of primary or secondary effluent.

## Appendix C

### Unit Process Description

#### 4.0 DISINFECTION

##### 4.1 LIQUID CHLORINE

Liquid chlorine is the benchmark against which other disinfection methods have historically been evaluated. Liquid chlorine is gaseous chlorine that has been compressed to a liquid state for ease of transportation and handling. It is converted back to the gaseous state at the point of application and injected into the wastewater to be disinfected. The standards for duration and intensity of disinfection have been set based upon the use of chlorine or one of the related chloride compounds, the most common being sodium hypochlorite.

Liquid chlorine can be toxic to humans if inhaled as a gas, and thus the transportation, handling, and storage of this product must be done in strict accordance with regulations to eliminate the potential risk of spillage. For the Deer Island site, the liquid chlorine risk issue was evaluated during the site selection impact studies. The Federal Environmental Impact Statement (EIS) included as a condition for the Deer Island site the following:

"...as a mandatory mitigation measure, if Deer Island is to be the site of the new treatment plant, liquid chlorine shall not be used at a new Deer Island treatment plant unless the MWRA can demonstrate to EPA during facilities planning that there is a clear and convincing need for the use of liquid chlorine and that it can be transported, handled, stored, and used in an environmentally acceptable manner."

This statement along with the associated text has been interpreted to mean that liquid chlorine will not be used unless there are no alternatives to the use of liquid chlorine. Therefore, since options utilizing sodium hypochlorite are feasible, liquid chlorine has been eliminated from further consideration.

##### 4.2 SODIUM HYPOCHLORITE

Sodium hypochlorite is applied as an aqueous solution. It can be commercially purchased in varying strengths. At wastewater treatment facilities it is typically purchased as a 15 percent solution by weight. At this strength one gallon of solution has approximately one pound of chlorine available in solution. Higher strengths can be purchased but the solution is unstable and will decrease in strength while in transit and storage. Weaker solutions can also be purchased, the most common being household bleach.

Sodium hypochlorite is dosed into the effluent and then held in contact for a specified period after which the residual chlorine level is measured as a means of evaluating disinfection efficiency. In Massachusetts the DEQE/DWPC relies upon the New England Interstate Standards for establishment of contact times. Those regulations require a 15-minute contact time at peak flow unless the discharge is to shellfish areas, in which case the contact time will be 30

minutes. It is assumed for area sizing that a 15-minute contact time is appropriate. The area required for contact would be approximately 2 acres. No allowance has been made for the time of travel within the outfall.

The supply of sodium hypochlorite to the Deer Island treatment facility would be accomplished by one of three methods:

1. Trucking of sodium hypochlorite solution
2. Barging of sodium hypochlorite solution
3. Onsite manufacture of sodium hypochlorite solution

Method 1 would involve a number of tank trucks travelling to and from the site either overland, or via a roll-on roll-off barge. Storage facilities would be necessary on the site. The sodium hypochlorite would be most likely manufactured by local chemical suppliers from liquid chlorine at existing or expanded production facilities. The trucking of sodium hypochlorite is commonly done, while the use of roll-on roll-off barges for transport is not known to be done as such; however, containers of sodium hypochlorite are transported on ships. Local harbormaster approval and Coast Guard concurrence will be required.

Method 2 would involve the purchase or lease of a bulk barge and customizing the barge, most likely to a double hull configuration, to protect against spills and the corrosive nature of the sodium hypochlorite. At present there are presently no known facilities for on-loading of barges. There is the potential for such facilities in areas such as Providence, Rhode Island, or Portsmouth, New Hampshire. The development of such facilities would require a long-term commitment from the MWRA to a local chemical supplier to justify the necessary capital investment. Additionally, approvals would be necessary from both the local harbor master as well as the Coast Guard. The travel time for such bulk barge deliveries would require that on-site storage be provided to guard against interruptions due to inclement weather. It is assumed that a minimum of five days reserve should be maintained at all times. The area needed for storage would be approximately 1 acre.

Method 3 would involve the on-site generation of sodium hypochlorite by electrolytic methods. Such systems are commercially available units and have been used at varying facilities ranging from off-shore oil platforms, nuclear power plants, and wastewater treatment facilities. The systems are modular in nature and can theoretically be constructed to produce sufficient quantities of sodium hypochlorite for the proposed site. The systems require significant amounts of power. They must be routinely maintained by means of acid cleaning and replacement of the sacrificial anode/cathode every 3 to 5 years. The required area is less than an acre, not including storage for peak demand. The strength of the solution produced is relatively weak.

#### 4.3 OZONE

Ozone has been used as a disinfectant for drinking water for a number of years in Europe and has recently become quite common in this country. Its use for the disinfection of secondary effluent wastewater is not very common. It has been used for disinfection of tertiary

wastewaters and for specific chemical wastewater polishing -- most notably with cyanide wastes.

Ozone can be produced from either air or oxygen. Both systems require significant amounts of electricity for their operation. The systems also produce noise, particularly the oxygen system compressors. The contact time required is minimal -- three to five minutes. Measurement of ozone's effectiveness is difficult and therefore requires that overdosage be practiced. There is believed to be no negative impact upon the receiving waters based upon information available to date.

#### 4.4 ULTRAVIOLET IRRADIATION

Ultraviolet irradiation as a means of disinfection was essentially nonexistent 15 years ago. The EPA's I/A program led to the rapid development of ultraviolet irradiation as an acceptable method of disinfection. The system's effectiveness is dependent upon the transmissivity of the effluent, and the strength and duration of the UV dosage applied. Practically, this has meant that the UV source, which resembles a florescent lamp, must be placed within 1 to 3 inches of the bacteria to be destroyed. There are presently two principal types of systems: (1) the effluent is passed in trays below the UV source; or (2) banks of UV tubes are immersed within a channel with effluent flowing around them. The first type of system is most appropriate for very low flow plants (less than 1 mgd).

There is limited literature available to accurately predict the effectiveness of UV on a primary effluent. Tests of UV for disinfection of CSO wastewater have been conducted. The strength of the CSO in the test was greater than the average influent to the proposed STF plant. The UV disinfected the CSO to values of 1200 to 1600 MPN/100 ml fecal coliform. Further analysis is necessary to predict the effectiveness of UV on the proposed primary effluent.

An in-channel UV system would require that multiple channels be available. There is no easy method for determining the effectiveness of the disinfection; therefore, overdosage would have to be practiced. There is no evidence of negative impact upon the receiving waters. The required detention times are quite short -- four to six minutes.

## **Appendix D**

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**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix D**

**Noise and Sound Data, Point Shirley**

## 1.0 INTRODUCTION

Noise associated with the construction and operation of the new Deer Island Wastewater Treatment Facilities has the potential for creating a noise impact on portions of the Town of Winthrop, particularly in the Point Shirley area, adjacent to Deer Island and at Quincy Great Hill, adjacent to Nut Island. To minimize the noise impact, noise control requirements have been incorporated into the treatment facilities planning process through the use of noise evaluation criteria. These criteria have been employed in judging the effectiveness and acceptability of noise controlling alternatives as they apply to selection of wastewater treatment equipment, site planning, and construction.

This report describes the development of the noise evaluation criteria, considerations given to the noise prediction methodology, evaluation of noise control requirements for alternative treatment facility processes, predictions of construction noise and noise from the recommended facility operation, and recommendations for implementing a noise control plan.

## 2.0 SELECTION OF NOISE IMPACT ASSESSMENT CRITERIA

### 2.1 INTRODUCTION

Noise impact assessments usually rely on baseline noise levels for judging the magnitude and acceptability of incremental noise changes. Several brief baseline noise surveys were previously made within the Point Shirley study area relating to multiple site assessments and specialized projects. These were reported in Supplemental Draft Environmental Impact Statement on Siting Of Wastewater Treatment Facilities For Boston Harbor, 1986; Thibault/Bubly Associates, 1986; MWRA, Notice of Project Change, July 1986; Final EIR On Siting Of Waste Water Treatment Facilities For Boston Harbor, 1985. These surveys sampled ambient noise for periods of a few minutes up 24 hours. A more extensive study was required for this analysis to provide a firm statistical basis for the development of recommended noise criteria for Deer Island. The results of this survey, and recommendations for construction and operational noise criteria are summarized herein.

### 2.2 REGULATIONS AND GUIDELINES

The assessment of noise impact involves determining both the increase in ambient noise and compliance with appropriate regulations. Three noise regulations are potentially applicable to the site and are summarized as follows:

The City of Boston Noise Regulations address various sources of noise and set specific noise limits for the transmission of sound between properties of the same and different zoning. The allowable noise level transmitted to a residential zone during the daytime hours of 0700 to 1800 is 60 dBA. A 50 dBA level is allowable during the remaining nighttime hours. The maximum allowable noise level allowed to be transmitted to an industrial site is 70 dBA. The code also

has corresponding octave band level requirements.

The Boston noise code limits construction noise at the residential and institutional property lines to an L10 level (the level exceeded 10% of the time) of 75 dBA and a maximum level of 86 dBA. The allowable L10 for recreational land is 80 dBA. Construction is not permitted at night or on weekends unless the construction noise level at the residential property line does not exceed 50 dBA.

The State of Massachusetts Department of Environmental Quality (DEQE) guidelines on noise allow a new facility to increase the ambient noise a maximum of 10 dBA over the existing L90 ambient noise. The L90 levels are the lowest values measured at night. The measurements of the ambient sound level and the resulting DEQE requirements are discussed in later sections of this report. The DEQE guidelines also prohibit the emission of a pure tone from noise sources. A pure tone is defined as occurring when the level in one octave band exceeds the level in the two adjacent octave bands by 3 dB or more.

All equipment on the site will be required to conform to the U.S. Department of Labor's Occupational Safety and Health (OSHA) requirements on noise exposure. These regulations allow an equivalent 8-hour exposure of 90 dBA for the protection of employee hearing. Where equipment cannot be purchased to meet OSHA noise exposure requirements, noise mitigation will be added as required.

### 2.3 AMBIENT SOUND LEVEL SURVEY

For this report an ambient sound level survey was conducted at Point Shirley, in the Town of Winthrop, in the nearest areas potentially impacted by facility construction and operation noise. The goals of the survey were the following:

- 1) Establish the spatial variation in the ambient sound levels throughout Point Shirley.
- 2) Establish the diurnal (day vs night) variation in the sound levels.
- 3) Determine the temporal variability of sound levels from day to day.
- 4) Identify the sources of noise controlling the ambient levels.

#### 2.3.1 MEASUREMENT LOCATIONS

A preliminary inspection of the study area indicated that the primary noise sources were Logan Airport, traffic on Tafts Avenue and other local roads, surf noise from the beaches, and, occasionally, the existing treatment plant. Previous studies indicated that the Nordburg diesel drives on the existing wastewater pumps were sometimes audible.

The prior noise surveys also assessed the sound levels throughout Winthrop and concluded that the mainland portion of Winthrop had nighttime L90 levels in the 34-40 dBA range, whereas Point

Shirley was slightly louder, in the 40-43 dBA range. However, because of the much greater distance to the other parts of Winthrop, criteria selected for Point Shirley will serve as a conservative criteria for the balance of Winthrop.

Noise measurement locations were selected to provide data on each of the sources discussed above to be spatially distributed across Point Shirley. A map of the locations is given in Figure D-1. All of the locations except No.1 have line-of-sight shielding by houses from the airport and surf. Location 1 was shielded by a house from the diesel pump station noise. Locations 2 and 3 had line-of-site visibility to the diesel pump station.

Two types of noise survey methodologies were used in conjunction with each other to provide a complete description of the spatial and temporal variation in sound levels. The first type consisted of the continuous monitoring of sound levels sequentially at locations 1 and 3, shown in Figure D-1, for 17 days. Locations close to the plant were selected for the continuous monitoring of the existing sound levels because the potential for adverse noise impact is the greatest there. The monitor was periodically calibrated throughout the survey. Continuous monitoring allowed the collection of a more extensive data base than is possible with staffed surveys.

The second type of survey was staffed, and measurements were taken with portable instrumentation. During these surveys 10-minute statistical samples of sound levels were taken, and on 3 out of 5 of the surveys, residual octave band measurements were also taken. The staffed surveys enabled a number of locations to be measured and the sources of noise noted. The staffed surveys were conducted during 2 to 3 hour periods during the day and nighttime hours at locations 1, 2, 4, 5, 6, and 7.

### 2.3.2 INSTRUMENTATION

A Larson Davis 800 Noise Analyzer and a Bruel and Kjaer 2215 sound level meter were used manually to measure the residual octave band sound pressure levels and A-weighted sound level statistics. The residual octave band measurements were taken in the absence of transient noise such as passing vehicles and aircraft landings. Ten-minute statistical samples of the A-Weighted sound level were taken by reading the meter every 10 seconds and preparing a histogram of the data. All measurements were taken with local winds at less than 10 mph.

A Larson-Davis 700 Noise Dosimeter was used to continuously measure and statistically analyse the variable ambient noise. The device was programmed to provide hourly statistics including the L10, L50 and L90 values, that is, the level exceeded 10%, 50% and 90% of the time. The L90 value typically represents the residual, or background level which occurs when transient noise is absent.





## 2.4 SURVEY RESULTS AND DISCUSSION

### 2.4.1 MANUALLY COLLECTED DATA

The manually collected data discussed above is presented in Tables D-1 through D-5. Most of the L90 sound level data taken at some distance from the water (locations 4, 5, and 6) were in the 42-47 dBA range. Measurements taken from locations, which are more exposed to surf noise (locations 1, 2, 3, and 7), were sometimes several decibels higher.

During the day and evening hours the intervals of time between aircraft takeoff and landing noise were observed to be infrequent and brief. However, after the hours of approximately 2300 to 2400, takeoffs and landings became infrequent and the residual levels appeared to be controlled by surface aircraft operations at Logan Airport, surf noise, and occasionally the Nordburg diesel drives of the waste treatment pumps on Deer Island.

In general, the more sheltered locations, i.e., those away from the shore, were 5 to 6 dBA quieter than those near the water because these locations were partially shielded by houses from Logan ground operations, surf, and occasionally diesel noise. This was also observed in the field by measuring the noise primarily from surface aircraft operations, first from behind a house and then with line-of-sight to the airport.

The pump station diesels were inaudible at all locations when the winds were northerly. This is because the vertical gradient in wind speed tends to raise the upwind sound wave off the ground and creates an acoustical shadow zone. However, when the winds had a southerly component, i.e., from the direction of the diesels, the diesels were, on occasion, audible at one or two measurement locations which varied from survey to survey. Diesel audibility is indicated in Tables D-1 to D-5.

When audible, the diesel sound varied in an irregular, pulsing manner, caused by multiple diesel units operating at slightly different speeds. Most of the diesel noise was in the 63 Hz octave band, corresponding to the cylinder firing rate. At one of the measurement locations, the diesels caused a 4-dBA variation in the sound level when measured with the sound level meter on "fast" response. The level in the 63 Hz band on "fast" response varied from 5 to 10 dB. On "fast" response the meter's response time is reduced and the meter becomes very sensitive to rapid changes in sound level. All other measurements were taken on "slow" response, as is standard practice for community noise measurements.

### 2.4.2 CONTINUOUS MONITOR DATA

A tabulation of the data from the continuous monitor first used at Location 1 and then at 3 is given in Attachment D-1. This data describes the diurnal variation in sound level for 13 days at Location 1 and five days at Location 3.

The L90 data were divided into meaningful time periods and sorted to examine the group



TABLE D-1

**AMBIENT SOUND PRESSURE LEVELS,  
September 3, 1986, Winthrop, MA**

MEASUREMENT LOCATION (TIME OF SURVEY)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ								
		31	63	125	250	500	1000	2000	4000	8000
1. Engineers House		Not Collected								
2. 150 Tafts (1300-1310)	45	Not Collected								
4. Tafts & Otis (1337-1347)	43	Not Collected								
5. Shirley & Triton (1450-1500)	44	Not Collected								
6. Siren & Triton (1414-1424)	40	Not Collected								
7. Harbor View (1500-1510)	42	Not Collected								

NOTE:

Weather conditions: Wind E, < 5 mph, overcast.

TABLE D-2

**AMBIENT SOUND PRESSURE LEVELS,  
September 5, 1986, Winthrop, MA**

MEASUREMENT LOCATION (TIME OF SURVEY)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, Hz									
		31	63	125	250	500	1000	2000	4000	8000	
1. Engineers House		Not Collected									
2. 150 Tafts (1000-1015)	51	58	60 <sup>1</sup>	63	53	42	37	33	28	25	
4. Tafts & Otis (1037-1047)	43	55	55	50	41	38	38	30	30	17	
5. Shirley & Triton (1053-1104)	42	55	58	51	49	45	40	32	27	20	
6. Siren & Triton (1115-1126)	44	57	57	53	45	38	35	29	29	21	
7. Harbor View (1139-1152)	49	61	60 <sup>2</sup>	57	49	44	41	37	32	32	

NOTE:<sup>1</sup> Diesels just audible, pulses to 70 dB.<sup>2</sup> Diesels audible, pulses to 65 dB.

Weather conditions: Wind Light, Southerly, Sky Clear.

TABLE D-3

**AMBIENT SOUND PRESSURE LEVELS,  
September 16, 1986, Winthrop, MA**

MEASUREMENT LOCATION			RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ									
(TIME OF SURVEY)			L90 dBA	31	63	125	250	500	1000	2000	4000	8000
1.	Engineers House	53	60	65	60	56	56	49	44	38	27	
2.	150 Tafts (2200-2210)	48	Not Collected									
4.	Tafts & Otis (2300-2310)	47	Not Collected									
5.	Shirley & Triton (2420-2430)	46	Not Collected									
6.	Siren & Triton (2339-2349)	46	Not Collected									
7.	Harbor View (2358-0008)	48	Not Collected									

NOTE:

Weather conditions: Winds N at 5 mph.

TABLE D-4

**AMBIENT SOUND PRESSURE LEVELS,  
September 1718, 1986, Winthrop, MA**

MEASUREMENT LOCATION (TIME OF SURVEY)			L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ								
				31	63	125	250	500	1000	2000	4000	8000
1.	Engineers House		47	60	65	56	51	43	40	27	33	19
2.	150 Tafts (0010-0024)		40	55	60 <sup>1</sup>	53	42	35	29	22	18	15
4.	Tafts & Otis (2355-0005)		38	51	52	49	41	36	29	22	15	14
5.	Shirley & Triton (2338-2350)		42	55	55	56	49	39	34	26	22	15
6.	Siren & Triton (2322-2333)		47	57	57	52	50	46	39	28	25	16
7.	Harbor View (2304-2314)		48	53	61	52	45	41	38	38	32	20

NOTE:

<sup>1</sup> Diesels audible, level varies to 70 dB with pulses.

Weather conditions: Wind SW Light to calm.

TABLE D-5

**AMBIENT SOUND PRESSURE LEVELS,  
September 1819, 1986, Winthrop, MA**

MEASUREMENT LOCATION			L90	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ								
(TIME OF SURVEY)			dBA	31	63	125	250	500	1000	2000	4000	8000
1.	Engineers House (0025-0036)	48	60	65 <sup>1</sup>	57	47	42	37	32	28	18	
2.	150 Tafts (2335-2345)	46	57	60 <sup>1</sup>	54	46	40	36	32	28	23	
4.	Tafts & Otis (2314-2325)	42	56	58	55	44	38	34	27	26	18	
5.	Shirley & Triton (2242-2252)	44	57	57 <sup>2</sup>	55	45	40	36	32	30	23	
6.	Siren & Triton (2250-2309)	43	56	59	51	45	40	34	28	20	22	
7.	Harbor View (2216-2227)	50	55	60	55	46	45	40	36	35	32	

NOTE:<sup>1</sup> Diesel audible, 70 dB peak.<sup>2</sup> Perhaps, just audible.

Weather conditions: Winds SW, very light.

statistics. The L90 sound levels for the nighttime period of 2300 to 0600 were grouped together and sorted to determine their percentiles of exceedence. During this period of time it is likely that a significant percentage of the population would be sleeping.

This analysis indicates that 50 percent of the nighttime L90 values were greater than 45 dBA, indicating that 45 dBA is a typical value for the nighttime L90 sound level. The 90 percentile value of the L90 sound level was 39 dBA. Thus, for most hours, the L90 sound level at that location exceeds 39 dB. The lowest hourly L90 value measured was 35 dBA at location 1.

A similar analysis was performed for the daytime hours of 0700 to 1800. It is not yet known what the specific hours of construction will be, but this time period includes the most common periods of construction. The quietest hour during this period was 41 dBA. However, 90 percent of the time the L90 levels were in excess of 45 dBA, and 50 percent of the time they exceeded 51 dBA. These data are summarized in Table D-6. These measurements generally agree with the previous shorter-term assessments on noise at Point Shirley referenced in Section 2.0.

## 2.5 RECOMMENDED CRITERIA

Two noise assessment criteria are required: one for assessing the noise from daytime activities such as construction and operation of the facility; and one for assessing the nighttime operation of the facility. These criteria differ because the ambient sound level and household activities change from day to night.

Criteria selection involves choosing the lowest ambient sound level likely to occur, because it is at this time that any new intrusive noise will be the most obvious and have the greatest impact. Obviously, the longer the ambient sound levels are sampled, the more likely an even lower value will be measured.

The analysis discussed in Section 2.4.2 indicates that the nighttime hourly ambient L90 sound level is greater than 39 dBA 90 percent of the time; therefore it is recommended that 39 dBA be used to assess the maximum nighttime noise impact at the property line. Other portions of Winthrop are much further away from Deer Island and will receive adequate protection with the same criterion. This results in a DEQE requirement of 49 dBA for the allowable 10 dBA above ambient stipulated in the Massachusetts DEQE Regulation 10 of the Air Pollution Regulations. It is not recommended here that a 49 dBA level is the design goal, but rather a legal requirement which the site operational noise must, and will, meet.

In a similar manner, the criterion for assessing daytime noise impact was determined to be 45 dBA. Construction planning will address the timing of construction activities. Since the lowest ambient noise levels occur during the middle of the day and the middle of the night, the maximum impact assessment criteria remain essentially the same during the evening as during the day.

A summary of the noise impact assessment criteria are shown in Table D-6 for both daytime and nighttime impact assessment. These criteria are recommended to be used as the ambient basis

TABLE D-6

**SUMMARY OF NOISE ASSESSMENT CRITERIA, dBA  
POINT SHIRLEY, TOWN OF WINTHROP**

	L90
-----	
Daytime 0700-1800	45
Nighttime 2300-0600	39
-----	
DEQE nighttime operation noise limit, no pure tone	45
DEQE daytime operation noise limit, no pure tone	51
OSHA on-site 8 hour exposure limit	90



for assessing the impact of construction and operation noise, determining acceptable noise control techniques, and determining noise mitigation measures.

In summary, the ambient (L90) for assessing maximum nighttime and daytime noise impact in the Point Shirley area are 39 and 45 dBA, respectively. Predicted construction and operation noise levels will be compared with these levels in future analyses to determine the need and amount noise mitigation. The DEQE level not to be exceeded for a constant nighttime operation noise was determined to be 49 dBA.

### **3.0 FACTORS AFFECTING SOUND PROPAGATION**

#### **3.1 INTRODUCTION**

During the course of making noise predictions for construction and operation of the facility, assumptions must be made regarding several factors which affect the noise propagation calculations, namely atmospheric absorption, anomalous attenuation, and barrier attenuation. This section discusses the selection of these factors and methodologies which have been used for the project.

#### **3.2 SELECTION OF ATMOSPHERIC ABSORPTION COEFFICIENTS**

##### **3.2.1 INTRODUCTION**

This section describes the methodology used to select site specific Minimum Atmospheric Absorption Coefficients (MAACs) which will be used for predicting noise impact from the construction and operation of the Deer Island Wastewater Treatment Facility. The MAAC defines the absorption of sound by the atmosphere in decibels per 100 meters for all temperature and humidity combinations, and vary by a factor of approximately four from their highest to lowest values for a given audio frequency. Often the MAACs for typical conditions of 15 degrees C and 70% relative humidity are used for this purpose, but in an effort to make the noise predictions conservative, site specific MAACs were developed from the applicable American National Standards Institute (ANSI) standard, utilizing the specific sound frequencies of concern, and a statistical analysis of five years of weather data recorded at Logan International Airport.

Atmospheric absorption of noise is a complex function of temperature and humidity. The higher the frequency, the greater the atmospheric absorption. However, there is no single set of meteorological conditions which gives minimum absorption at all frequencies. The conditions which give minimum absorption for one frequency give maximum absorption at another, etc. Thus, the MAACs must be examined in detail to select the appropriate conditions for the frequencies being studied.

##### **3.2.2 APPROACH**

The purpose of this analysis was to identify the MAACs that will occur at the site. Briefly,

the approach used was to 1) identify the MAAC for each temperature range, 2) determine which octave band frequencies are the ones of primary importance for noise propagation, 3) choose the weather conditions which give minimum absorption for the octave bands of concern, and 4) evaluate the frequency of occurrence of the weather conditions which produce the lowest MAACs. Absorption coefficients were selected from the ANSI standard entitled, "Method for the Calculation of the Absorption of Sound by the Atmosphere" (ANSI S1.26-1978). The approach is described below:

### 1. Identify MAACs

1a. Using the atmospheric absorption coefficient table of the standard, (Attachment D-2) for each temperature classification (0, 5.0, 10.0 degrees C, etc.), the lowest value of the AAC was underlined for each of the octave band center frequencies, as shown in the Attachment.

### 2. Determine significant octave band frequencies

2a. A curve was plotted for each octave band center frequency of MAAC vs. temperature as shown in Figure D-2

2b. The variation of sound absorption at 800 m from the site was determined as the MAAC ranged from its lowest to its highest value. This was determined by multiplying the MAAC by 8 (for 800 meters) and dividing by 2 to get the range. ( $\text{MAAC} \times 8 \text{ m}/2$ ). 800 m was used as a typical distance from power generation facilities on the site to the nearest neighbor. This number, shown in Table D-7 illustrates the sensitivity of the far-field sound level to variations in the MAAC.

From the table it is determined that at 125 Hz, the range in MAACs will cause a variation of  $\pm 0.08$  dB in the sound level at 800 m. Likewise the variability at 250 and 500 Hz is  $\pm 0.2$  and  $\pm 0.4$  dB respectively. It can be seen that the variability at 125 and 250 Hz is so small that the weather dependence of the MAAC can be ignored.

2c. It may be further observed that frequencies of 4000 Hz and higher are of no concern because they are attenuated so much with distance that they have no impact on the sound level. For instance, at 800 m the 4000 Hz MAAC gives 22 dB more attenuation than at 2000 Hz. In addition, construction and operation noise is usually very low at 4000 Hz. Thus high frequency noise is not generally of concern for construction and operation noise.

### 3. Select Meteorological Conditions

It has been demonstrated in steps 2b and 2c that only the 500, 1000, and 2000 Hz octave bands need be considered in selecting meteorological conditions giving minimum MAACs.

It can be observed from that portion of the curves within the box of Figure D-2 that the

TABLE D-7

VARIABILITY OF SOUND ABSORPTION AT 800 M AS THE MINIMUM ATMOSPHERIC  
ABSORPTION COEFFICIENT (MAAC) RANGES FROM ITS LOWEST TO HIGHEST VALUE

## OCTAVE BAND CENTER FREQUENCIES

63	125	250	500	1000	2000	4000	8000
-	<u>+0.1</u>	<u>+0.2</u>	<u>+0.4</u>	<u>+1.2</u>	<u>+3.2</u>	<u>+6.0</u>	-

MINIMUM ATMOSPHERIC ABSORPTION COEFFICIENT

FREQUENCIES  
OF CONCERN

1000 Hz

2000 Hz

4000 Hz

500 Hz

100 Hz

10 Hz

TEMPERATURE, DEGREES C

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

FIGURE D-2  
MINIMUM ATMOSPHERIC ABSORPTION  
COEFFICIENTS VS. TEMPERATURE  
FOR EACH FREQUENCY



500, 1000, and 2000 Hz MAACs occur at 0 degree, 0 degree, and 10 degree C, respectively. The 0 degree C meteorological condition was selected as the design basis because it has the lowest MAACs for 2 of the 3 curves within the box. As can be seen from Attachment D-2, for 0 degree C., the lowest MAAC is at 100% Relative Humidity (RH).

#### 4. Frequency of Meteorological Conditions

A statistical sort was then performed on five years of weather data from Logan International Airport as shown in Table D-8. It can be seen that the conditions of 0 degrees C and 100% RH which give the MAAC occur 1.9% of the time, i.e., 14 hours per month average for the six winter months where this condition is likely to occur. The design basis MAACs selected were therefore the ANSI values for 0 degree C, 100 percent RH as given in Table D-9.

#### 3.2.3 Conclusion

The minimum atmospheric absorption coefficients which will give the maximum sound levels in the community have been identified based on site weather conditions. These values are conservative, and most of the sound levels will be lower than predicted. In contrast, the greatest atmospheric absorption coefficient which occurs with any significant frequency, for instance at 1000 Hz, is that for 0 degrees C, 30% RH, which is 1.08 dB/100 m. This provides an additional 6 dB absorption in 800 meters over the MAAC. This means that when maximum absorption is occurring at 1000 Hz the 800 m, 1000 Hz sound levels will be 6 dB lower.

#### 3.3 ANOMALOUS ATTENUATION

The term anomalous attenuation is generally used to describe attenuation caused by factors other than atmospheric absorption, vegetation, and barriers. Values are sometimes presented in decibels per 100 m in the same manner as atmospheric absorption. There is, at this time, however, no general consensus as to what these values should be, or whether or not they should be used.

For instance Kurze and Beranek (1971) evaluated extensive field data collected near Leningrad over a several year period and came up with a design guide for including this factor in propagation calculations. More conservative values are included in a design guide prepared by Miller, et.al.(1978). The use of this factor is not uncommon in engineering calculations.

However, in a recent summary of outdoor noise propagation schemes, Embleton (1982), indicates that during night time downwind noise propagation, the measured absorption can be accounted for solely with distance and atmospheric absorption corrections. This is because temperature inversions cause sound to be refracted downward, and the attenuation provided by ground effects is eliminated. The data presented therein by Parkin and Scholes (1965) confirmed this postulate.

TABLE D-8

**DISTRIBUTION OF RELATIVE HUMIDITY VERSUS DRY BULB TEMPERATURE  
LOGAN AIRPORT, BOSTON, MA (1970 - 1974)**

Dry Bulb Temperature (Degrees)F	Relative Humidity (Percent)										Temperature Degrees C
	0- 14	15- 24	25- 34	35- 44	45- 54	55- 64	65- 74	75- 84	91- 100	Total	
0 - 26	0	21	292	680	920	821	418	443	95	3690	
Pet Class	0.0	0.57	7.91	18.43	24.93	22.25	11.33	12.01	2.57	100.0	
Pet Total	0.0	0.05	0.67	1.55	2.10	1.87	0.95	1.01	0.22	8.42	
27 - 36	0	38	182	634	1183	1311	897	1487	836	6568	0
Pet Class	0.0	0.58	2.77	9.65	18.01	19.96	13.66	22.64	12.73	100.00	
Pet Total	0.0	0.09	0.42	1.45	2.70	2.99	2.05	3.39	1.91	14.99	
37 - 45	2	21	254	562	1025	1176	1473	2364	663	7540	5
Pet Class	0.03	0.28	3.37	7.45	13.59	15.60	19.54	31.35	8.79	100.00	
Pet Total	0.00	0.05	0.58	1.28	2.34	2.68	3.36	5.40	1.51	17.21	
46 - 54	0	62	251	506	802	1020	1045	2112	977	6775	10
Pet Class	0.0	0.92	3.70	7.47	11.84	15.06	15.42	31.17	14.42	100.00	
Pet Total	0.0	0.14	0.57	1.15	1.83	2.33	2.30	4.82	2.23	15.46	
55 - 63	0	55	161	368	600	875	1000	2551	1154	6764	15
Pet Class	0.0	0.81	2.38	5.44	8.87	12.94	14.78	37.71	17.06	100.00	
Pet Total	0.0	0.13	0.37	0.84	1.37	2.00	2.28	5.82	2.63	15.44	
64 - 72	0	55	214	418	624	937	1388	2940	611	7187	20
Pet Class	0.0	0.77	2.98	5.82	8.68	13.04	19.31	40.91	8.50	100.00	
Pet Total	0.0	0.13	0.49	0.95	1.42	2.14	3.17	6.71	1.39	16.40	

TABLE D-8

**DISTRIBUTION OF RELATIVE HUMIDITY VERSUS DRY BULB TEMPERATURE  
LOGAN AIRPORT, BOSTON, MA (1970 - 1974)**

Dry Bulb Temperature (Degrees)F	Relative Humidity (Percent)										Temperature Degrees C
	0- 14	15- 24	25- 34	35- 44	45- 54	55- 64	65- 74	75- 90	91- 100	Total	
73 - 81	0	22	134	415	751	824	918	876	9	3949	25
Pct Class	0.0	0.56	3.39	10.51	19.02	20.87	23.25	22.18	0.23	100.0	
Pct Total	0.0	0.05	0.31	0.95	1.71	1.88	2.10	2.00	0.02	9.01	
82 - 90	0	6	114	343	367	324	62	1	0	1217	30
Pct Class	0.0	0.49	9.37	28.18	30.16	26.62	5.09	0.08	0.0	100.0	
Pct Total	0.0	0.01	0.26	0.78	0.84	0.74	0.14	0.00	0.0	2.78	
91 - 99	0	1	11	71	43	0	0	0	0	126	35
Pct Class	0.0	0.79	8.73	56.35	34.13	0.0	0.0	0.0	0.0	100.00	
Pct Total	0.0	0.00	0.03	0.16	0.10	0.0	0.0	0.0	0.0	0.29	
100 - 108	0	0	0	0	0	0	0	0	0	0	40
Pct Class	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Pct Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total	2	281	1613	3997	6315	7288	7201	12774	4345	43816	
Pct Class	0.00	0.64	3.68	9.12	14.41	16.63	16.43	29.15	9.92	100.00	
Pct Total	0.00	0.64	3.68	9.12	14.41	16.63	16.43	29.15	9.92	100.00	



TABLE D-9

MINIMUM ATMOSPHERIC ABSORPTION COEFFICIENTS (MAACS) FOR USE IN  
PREDICTING MAXIMUM NOISE IMPACT FROM THE CONSTRUCTION AND OPERATION  
OF THE WASTE WATER TREATMENT FACILITY AT DEER ISLAND, dB/100m

OCTAVE BAND CENTER FREQUENCY

63	125	250	500	1000	2000	4000	8000
.01	.03	.08	.14	.32	.99	3.52	12.13

As per ANSI S1.26 - 1978, 0° C, 100% RH

Because of the lack of a general consensus on this subject, it is proposed that factors for anomalous attenuation not be included in the noise predictions for this project. This will provide conservative, worst case noise predictions.

### 3.4 BARRIER ATTENUATION

A number of barrier attenuation calculation methodologies have been proposed and discussed in the literature over a period of several decades. Summaries of barrier methodology include those given by Kurze (1974) and Gill (1980). Perhaps the most widely used and simple approach is that developed by Maekawa (1971) and presented in various forms by other investigators. This approach is used by Kurze and Beranek in Beranek's "Noise and Vibration Control" (1971) and by Piercy and Embleton in Harris' "Handbook on Noise Control" (1979). Gill (1980) evaluated the Maekawa methodology as well as other methods in his testing of barriers for mitigating construction noise and found it agreed very well with field tests.

Recently Kurze and Schreiber (1986) developed an additional correction to the Maekawa approach, which accounts for the degradation of barrier attenuation at distances beyond several hundred yards. It is proposed that the Maekawa formula and the Kurze correction term for weather effects be used to calculate a conservative, downwind barrier attenuation on this project.

The resulting formula is:

$$A = 10 \text{ Log } ( 3 + 20 w/z \times K )$$

where:

A = barrier attenuation

w = wave length of sound

z = path difference between straight line, barrier to receiver, and over the barrier

K = weather constant

## 4.0 ALTERNATIVE ANALYSIS

The purpose of this analysis was to evaluate the off-site noise for each alternative task or process in order to categorize the noise control engineering effort required as minimal, modest, or difficult. This evaluation was performed by estimating the sound level of each alternative at the nearest residence, approximately 2200 ft north on Tafts Avenue on Point Shirley. A preliminary judgement was then made as to the relative impact of the noise, and, where the predicted sound levels were significantly higher than the existing sound levels, appropriate conceptual noise mitigation was incorporated into the prediction.

The existing daytime ambient sound level was previously measured as 45 dBA, and the nighttime

ambient as 39 dBA (Screening Report, 1986). The goal of this analysis was to incorporate sufficient noise control to keep the estimated sound levels significantly below the ambient sound levels.

#### 4.1 ALTERNATIVE GRIT AND SCREENINGS DISPOSAL

##### 4.1.1 INTRODUCTION

The grit and screenings, which are currently landfilled near the southern end of Deer Island will be removed, transported to the tip of the island, and landfilled in a manner to prevent leaching of contaminants into the soil.

##### 4.1.2 SECURE LANDFILL ALTERNATIVE

This first alternative for the disposal of the grit and screenings will be to place them in a lined, secure landfill to be covered over with a landform. The sound level expected from this operation was predicted based on the equipment to be used. Sound level estimates of construction noise were made using the methodology of Barnes (1977), assuming equipment was operating all of the time, and the percentage of time at full load was as per Barnes.

The sound level estimate assumes hemispherical radiation, and atmospheric absorption as per the Screening Report (1986). No barriers were assumed, although the existing central drumlin forms an effective barrier for noise propagating northward. Noise propagation WNW toward the western edge of Point Shirley is relatively unimpeded.

The estimated sound level for this activity is 41 dBA for the energy average level (Leq) at the nearest neighbor on Tafts Avenue, Point Shirley. These estimated levels will occur during ideal noise propagating conditions. Often there will be additional attenuation due to absorption by the ground, wind shadows, and temperature and humidity conditions other than those of the conservative design conditions. The noise control engineering effort for this alternative is rated as minimal.

##### 4.1.3 CHEMFIX ALTERNATIVE

The grit and screenings removal is similar for both options. However, for this alternative, the material is shredded and stabilized with Chemfix before being landfilled. The additional noise of the shredder is therefore included. The sound level expected at the nearest neighbor for this operation with the shredder is 54 dBA. In order to make the shredder noise more compatible with the daytime ambient sound level of 45 dBA at the nearest neighbor, the shredder will require a partial enclosure blocking sound propagation to the north. The shredder enclosure will reduce the total noise from this activity to approximately 44 dBA. The level of noise control required for this option is therefore rated as moderate.

## 4.2 OUTFALL PIPE PROTECTION

The building of landforms on the south end of Deer Island will require the construction of a protective barrier over the existing treatment plant outfall to protect it from the additional load. This activity will include excavating the existing outfall pipe, driving sheet piling on either side, and capping over with concrete. The sound levels expected from this activity were calculated at the nearest neighbor, assuming no barrier attenuation. The equipment assumed in the calculation are backhoes, a front-end loader, pile driver, compressor, mobile crane, and dozers.

Sound level estimates of construction noise were made using the methodology by Barnes et. al. (1977). It was assumed that the equipment was operating all of the time and the percentage of time at full load is as per Barnes.

The sound level estimate assumes hemispherical radiation, and atmospheric absorption as per the Screening Report (1986). No barriers were assumed although the existing drumlin forms an effective barrier for noise propagating northward. Noise propagation to the WNW is relatively unimpeded.

The estimated sound level for this activity is 38 dBA for the energy average level (Leq). Peak levels for pile driving noise are expected to be approximately 55 dBA, which can be reduced to 45 dBA with a shroud.

These estimated levels will occur during ideal noise propagating conditions. Often there will be additional attenuation due to absorption by the ground, wind shadows, and additional atmospheric absorption from temperature and humidity conditions other than those of the conservative design conditions. The noise control engineering effort for this alternative is rated as minimal.

## 4.3 DRUMLIN REMOVAL

### 4.3.1 DRUMLIN REMOVAL AND LANDFORM CREATION

The southern section of the central drumlin will be excavated and moved to allow room for primary plant construction. Most of the drumlin material will be trucked around the east edge of the island for landform creation in the prison area, since this recommended plan assumes the decommissioning of the prison by 1989.

Portions of the excavated material will also be deposited throughout the narrow northern end of the island to relocate the island access road and raise the elevation to 130 ft, and to construct a narrow noise barrier berm at the extreme northern end of the island to elevation 150 ft to provide additional noise attenuation. The dominant sources of noise from this activity are the trucks delivering the drumlin material, the bulldozers and scrapers used to shape the landforms, and the compactors to be used on the north end of Deer Island. The

expected sound level for construction of the noise berm is approximately 61 dBA at Tafts Avenue on Point Shirley. Special quiet-wheeled bulldozers will be used, supplemented by a mobile crane. Construction of this noise barrier will take approximately one month. Thereafter, landfilling construction activities required to complete the raised, northern platform area will generate an estimated noise level of 51 to 48 dBA at Point Shirley, depending on the distance to the berm.

Construction of the higher northern landform, including trucks and drumlin removal, will not be shielded by the noise berm, but will result in noise levels of 57 dBA or less due to the distance from the community. A total of 350 days will be required for this landform construction at the northern end.

For the costing plan, it is assumed that for any alternative in which the prison is still occupied, it will be necessary to modify the northern area where fill from the central drumlin is placed, relative to the recommended plan. The security fence to the north of the prison will be the southern limit of any landfilling; therefore, the northern landform must be placed on top of the southern part of the raised platform at 130 ft elevation. The access road from Point Shirley to the island will be relocated to the western shore of the neck. A noise berm will be built as in the recommended plans using quiet-wheeled dozers to shield the community from subsequent activities on the raised platform.

In summary, at Point Shirley the energy average sound level (Leq) due to construction of the noise berm and excavation of the drumlin will be 61 dBA. This exposure will occur for about one month. The sound level will generally be below 54 dBA during construction of the platform, including trucks and drumlin removal, rising above this level for a brief period when activity is near the western edge of the platform. The sound level will rise again to 57 dBA when the landform is being built on top of the platform.

At the prison, the sound level resulting from the combined activities of drumlin removal and construction of the northern landform will be 61 dBA. This sound level will gradually rise to 83 dBA as the activity comes within 100 feet of the security fence.

A lesser amount of material will be moved south to increase the elevation of the southern portion of the island to 125 feet, and to create a higher landform to elevation 175 ft at the far southern end. The expected sound level at Point Shirley for this recommended plan activity will be approximately 49 dBA, assuming that no northern landforms are yet in place.

#### 4.3.2 SECURE LANDFILL CONSTRUCTION PLATFORM

The grit and screenings will be disposed of by placement in a lined, secure landfill to be covered with a landform. The sound level expected from this operation was predicted based on the equipment to be used, consisting of backhoes, a scraper, dozers, a compaction roller, five trucks, a grader and a mobile shovel. No barriers were assumed, although the existing central drumlin forms an effective barrier for noise propagating northward. Noise propagation WNW toward the western edge of Point Shirley is relatively unimpeded. The estimated sound level



for this activity is 47 dBA for the energy average level (Leq) at the nearest neighbor on Tafts Avenue, Point Shirley.

#### 4.3.3 TOTAL SOUND LEVELS

As indicated in the analysis above, the sound level expected at the nearest residence for the task of securing the landfill is 47 dBA. The outfall protection task will give a sound level of 39 dBA for most of the operation, with peak levels of 45 dBA for the silenced pile driving operation. The sound level expected for moving the southern end of the central drumlin is 49 dBA.

Construction of the higher northern landform will not be shielded by the noise berm, but will result in noise levels of 54 dBA or less due to the distance from the community. A total of 350 days will be required for this landform construction at the northern end.

For the costing plan, it is assumed that for any alternative in which the prison is still occupied, it will be necessary to modify the northern area where fill from the central drumlin is placed, relative to the recommended plan. The security fence to the north of the prison will be the southern limit of any landfilling; therefore, the northern landform must be placed on top of the southern part of the raised platform at 130 ft elevation. The access road from Point Shirley to the island will be relocated to the western shore of the neck. A noise berm will be built as in the recommended plans using quiet-wheeled dozers to shield the community from subsequent activities on the raised platform.

At Point Shirley the energy average sound level (Leq) due to construction of the noise berm and excavation of the drumlin will be 61 dBA. This exposure will occur for about one month. The sound level will generally be below 51 dBA during construction of the platform, rising above this for a brief period when activity is near the western edge of the platform. The sound level will rise again to 58 dBA when the landform is being built on top of the platform.

At the prison, the sound level resulting from the combined activities of drumlin removal and construction of the northern landform will be 61 dBA. This sound level will gradually rise to 83 dBA as the activity comes within 100 feet of the security fence.

A lesser amount of material will be moved south to increase the elevation of the southern portion of the island to 125 feet, and to create a higher landform to elevation 175 ft at the far southern end. The expected sound level at Point Shirley for this recommended plan activity will be approximately 49 dBA, assuming that no northern landforms are yet in place.

#### 4.4 ALTERNATIVE PROCESS NOISE

##### 4.4.1 INTRODUCTION

The expected sound levels were predicted for each alternative. The categorization of the level of effort for noise mitigation proceeded as follows. If equipment is to be enclosed in a



building for weather protection, but the noise predictions indicated that acoustical material is required on the walls and ceiling and the ventilation would have to be quieted, this would be classified as a "modest" amount of noise control. Alternatively, if more expensive construction is required to contain the noise, such as the use of double wall insulated steel, sound proof doors and custom exhaust mufflers, etc., this would be classified as a difficult requirement. If no significant amount of noise control is required, this was classified as a minimal requirement.

In the evaluation of the secondary treatment options, the air compressors were a major source of noise. Their sound power was estimated, based on horsepower for both the intake and compressor casing noise. It is assumed for this analysis that the exhaust noise is controlled by the piping.

When pump noise was predicted it was assumed that the major source of noise was the motor. Motor noise was predicted based on motor horse power as per the EEI Guide (1978).

#### 4.4.2 SECONDARY TREATMENT

##### Air Activated Sludge Option

This option includes air compressors and their drive motors which will be housed in the blower building. The primary sources of noise for this option are the compressor inlet and casings. The compressor casing noise for compression totalling 27,000 hp was estimated and corrected for the transmission loss of building, as per Faulkner (1976), with noise absorption materials on the inside, hemispherical spreading, and atmospheric absorption as derived in the Screening Report, for a sound level at the nearest neighbor of 16 dBA. For simplicity, the distance to the nearest neighbor for all estimates was assumed to be the same as that of the existing diesel building (2200 ft).

The predicted compressor inlet noise of 54 dBA was controlled with large intake silencers to 20 dBA. Thus, the total noise of the compressor case and intake noise is 16 plus 20 dBA, or 21 dBA at the nearest neighbor. The noise control engineering required to attain these levels was ranked as modest.

##### Oxygen Option

The cryogenic compressors total 12,000 hp. Their sound level was predicted in the same manner as in the option above to be 18 dBA at the nearest neighbor. The aeration equipment has 36 outdoor electric motors with a total of 4200 hp. Their expected sound level for relatively quiet motors is approximately 43 dBA. Partial enclosures may be required to lower this level to approximately 30 dBA. Full enclosures could reduce it even further, but are difficult to ventilate and will probably not be necessary. The noise control engineering required to attain these levels was ranked as modest.

### Coupled System Option

This system has a total compressor hp of 17,500 plus 7200 hp of wastewater pumping capacity housed in a building. The sound levels were predicted in the same manner as above, giving a nearest neighbor sound level of 19 dBA. The noise control engineering effort required to attain these levels was ranked as modest.

#### 4.4.3 STACKED VS UNSTACKED CLARIFICATION

The sound level from the RAS pumps (6000 hp) inside buildings was estimated to be 13 dBA at the nearest neighbor. This level would be similar for stacked or unstacked clarifiers. The noise control engineering effort required to achieve these levels was ranked as modest.

The stacked clarifier has the added advantage that it leaves space on the northern end of Deer Island for land forms which will attenuate noise, particularly construction noise.

#### 4.4.4 GRIT AND SCREENINGS

##### Grit Removal, Aerated

The sound level for the motors was less than 10 dBA at the nearest neighbor. The noise control engineering effort required to achieve these levels was ranked as minimal.

##### Grit Removal, Centrifugal

No significant noise sources. No noise control is required and the level of effort is ranked as minimal.

##### Disinfection

No significant noise sources are associated with the disinfection processes.

## 5.0 CONSTRUCTION NOISE PREDICTIONS

### 5.1 DEER ISLAND CONSTRUCTION NOISE

The construction of the facility will continue over a period of approximately 12 years. During that time numerous buildings, treatment facilities and earthen landforms will be constructed. This section describes the procedure used to predict construction noise and the expected sound levels at Point Shirley during this period.

The greatest potential for noise impact at Point Shirley will occur during the early portions of the project with the construction of the earthen land forms at the northern end of Deer Island. This construction will involve the movement and placement of large amounts of earth with a potential associated noise impact. Once in place this landform will provide some shielding for the balance of construction noise.

A methodology for reducing the sound level of the construction of the berm requires that the northern edge of the berm be kept at a higher elevation than the back portion of the berm. This will provide shielding of a major portion of the earth hauling and unloading activities on the berm.

Construction noise is predicted using a methodology presented in the Power Plant Construction Noise Guide (Barnes 1977). This approach is based on actual measurements of a large number of pieces of construction equipment and the monitoring of construction noise at numerous power plant construction sites. For a given set of equipment operating in a given area, the methodology can be used to predict far field sound levels.

The method gives the expected 50 ft sound level for several sizes of each type of construction equipment commonly used. Corrections are then made for the number of pieces of each type of equipment ( $+10 \log N$ ), for the percent of time the equipment is operating ( $-10 \log$  specified time/reference time period), and the percent of operation time that it is expected to be at full load.

The construction noise was calculated by tabulating the equipment to be used for each of the on-site construction projects for three month periods, correcting for the factors discussed above. The construction area was divided into three zones of increasingly greater distances from Point Shirley to facilitate the prediction of noise. The total sound level vs time was then calculated for each zone, correlated for the effect of the barrier, extrapolated to the nearest residence, and totaled for the three zones. The atmospheric absorption values developed by CDM and SWEC (1986) were used for the calculation.

#### 5.1.2 BARRIER NOISE ATTENUATION

Landforms will be created along the northern end of Deer Island to provide a visual and noise barrier. The height of this landform will vary from 30 to 120 feet above the general level of Deer Island. The noise attenuation provided by the landforms is a function of several factors including:

- o distance from the noise receiver to the barrier
- o distance from the noise source to the barrier
- o barrier height
- o wind direction

The first factor, the distance from the source to the barrier is constant, but the second factor, the distance between the construction equipment and the barrier, ranges to over 4000 ft. The further the source is from the barrier, the less attenuation it provides, although hemispherical divergence attenuation increases.

The barrier height varies from elevation 160 (approximately 30 ft above the general terrain of 130 ft) to 240 ft, with an effective barrier height of 110 ft. Most of the construction work on buildings will occur behind the 200 ft elevation of the barrier, giving an effective barrier height of 70 ft.

The fourth factor affecting barrier acoustical performance is the wind direction. At great distances sound waves refract over a barrier and curve downward in the downwind direction, effectively reducing the barrier height. In a similar manner, the sound waves refract upward in the upwind direction increasing the effectiveness of the barrier.

A portion of the construction noise is from the equipment building the landforms. In order to reduce the noise from the construction of the landform, the northern most edge of the landform will be constructed with quiet equipment, and will be 20 ft higher than the balance of the landform to shield the landform construction equipment from the residences. This quiet equipment consists of Terex front-end loaders which are approximately 72 dBA at 50 ft, rather than that of typical diesel driven equipment which are in the 80s.

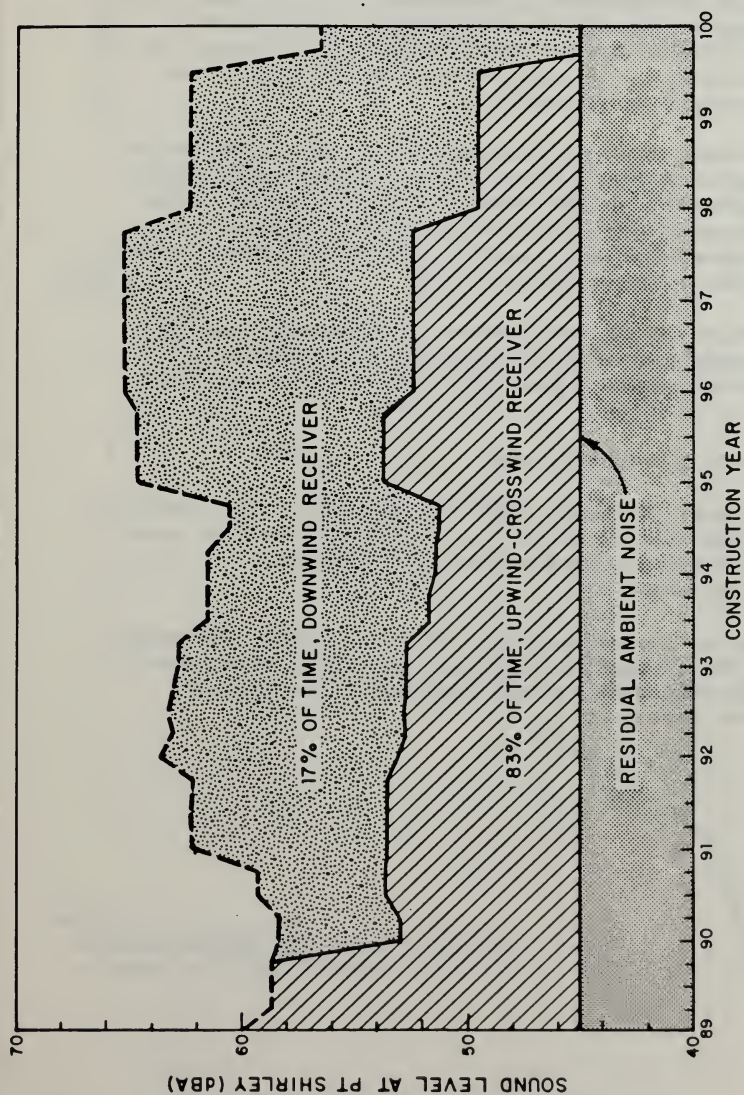
### 5.1.3 RESULTS

The sound levels at Point Shirley were analyzed with landforms to include both upwind, crosswind, and downwind conditions. The crosswind conditions were represented by using the barrier noise reduction methodology of Maekawa (1971). The upwind condition was represented by a 20 dBA wind shadow. (Wind shadows typically range from 20 to 50 dBA, Beranek 1971)

Although most barrier prediction techniques do not indicate barrier degradation with wind, in order to be conservative, the approach of Kurtz and Schreiber (1986) was used to determine the worst case effect of wind on barrier performance over long distances. This would occur with winds from the S, SE, and E.

The results of the estimates are given in Figure D-3. The curves show that the projected sound levels will vary between the existing minimum level of 45 dBA for a strong upwind condition, with the receiver in a wind shadow zone to 50-54 dBA with a cross wind, where the barrier effect of the landforms are responsible for reducing the noise. This range of sound levels is expected to occur on 83% of daytime hours. During 17% of the daytime hours (annual basis), when the wind has a SE component, the sound will tend to refract over the barrier and produce levels which vary from the low 50s to the 60-65 dBA range.





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FIGURE D-3  
PREDICTED DAYTIME CONSTRUCTION NOISE LEVELS  
AT NEAREST RESIDENCE, POINT SHIRLEY

The sound level contours were prepared showing construction noise for Point Shirley, representative of a loud construction period with approximately 63 dBA at the nearest neighbor. These contours are given in Figure D-4 along with the daytime ambient sound levels as previously measured. Not taken into consideration in the preparation of the contours is the 5+ dB reduction in noise observed at the site due to the barrier effect of the houses of Point Shirley for noise coming from low elevations.

This analysis has indicated that the noise barrier landform is an effective mitigation measure in reducing construction noise by about 10 dBA, for all but 17 percent of the daytime hours. The projected range in construction sound levels of 50 to 65 dBA were compared with the existing ambient, daytime sound measurements taken at Point Shirley. As shown in Figure D-4, the existing daytime median, or  $L_{50}$  sound levels, which range from 47 dBA to 63 dBA, are similar to the projected maximum construction sound levels.

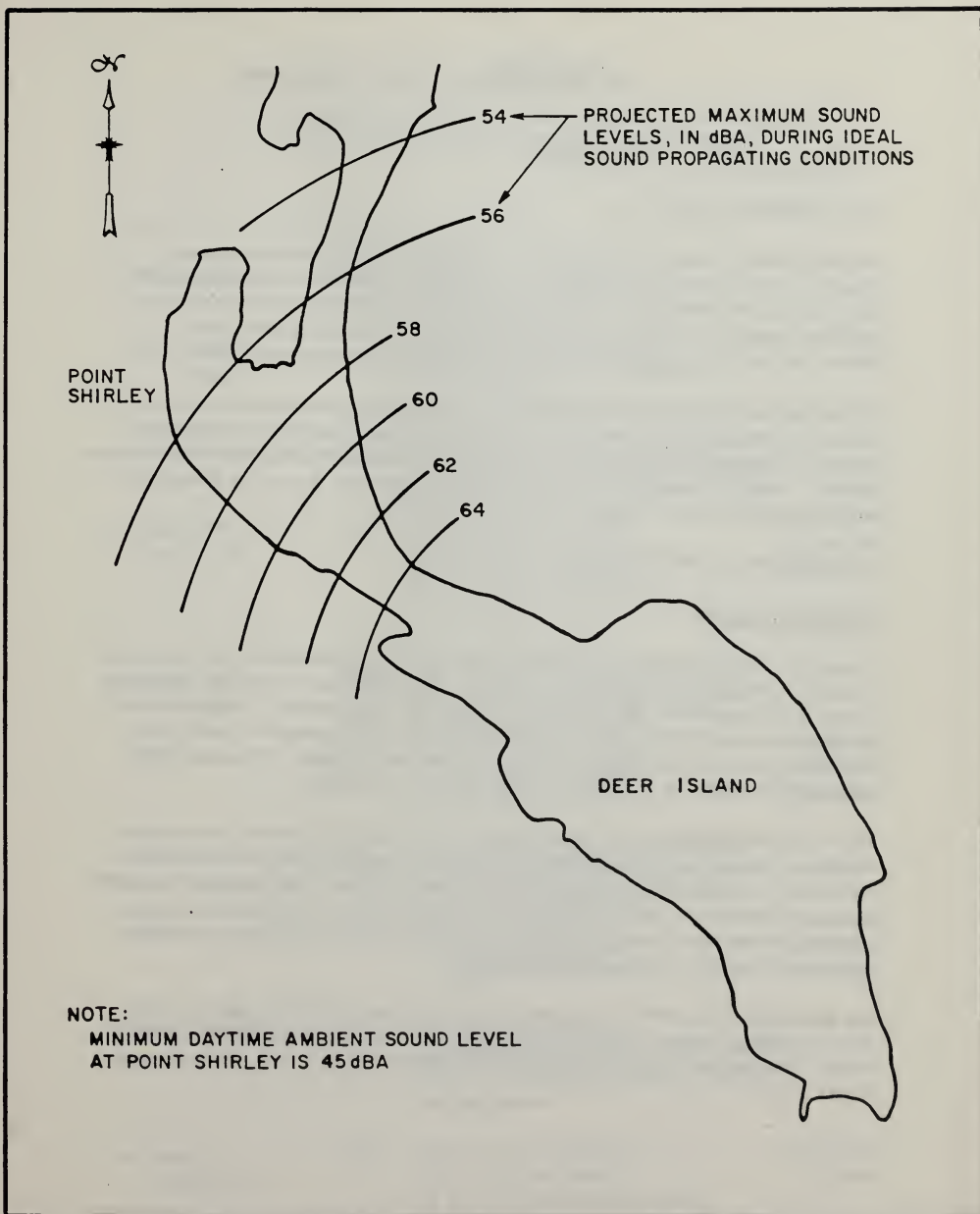
Under the worst-case conditions, downwind conditions limit the effectiveness of the noise barrier landform. Similar sound levels to the maximum projected for construction are characteristic of the area, and occur 97 percent of the daytime for about six minutes each hour.

#### 5.1.4 NUT ISLAND CONSTRUCTION NOISE

The construction noise for Nut Island was predicted in the same manner as that for Deer Island, but the amount of construction to occur is very small compared to Deer Island. The primary activities consist of the demolition of the existing facility, site preparation, and construction of the new building.

The energy average sound levels expected from the construction is expected to be 63 dBA from mid-1992 to mid-1994, then dropping to 60 dBA for the remaining year. This will result in an approximately 10 to 13 dBA increase over the measured daytime residual sound level if approximately 50 dBA for that period.





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FIGURE D-4  
MAXIMUM PROJECTED CONSTRUCTION SOUND  
LEVELS AT POINT SHIRLY, WINTHROP

## 6.0 OPERATIONAL NOISE PREDICTIONS

### 6.1 DEER ISLAND OPERATION NOISE

#### 6.1.1 INTRODUCTION

The Deer Island Wastewater Treatment Facility will include a large number of pumps, compressors, motor drives, a gas turbine, etc., which have the potential for creating audible off-site noise. This section describes an analysis which was performed to identify the significant potential contributors to off-site noise, estimate their sound levels in Point Shirley, and select the conceptual noise mitigation required to minimize noise impact.

The analysis demonstrates the technical feasibility of achieving a plant sound level which will have minimal impact on the Point Shirley area. It also indicates that there is a considerable amount of equipment which will need noise mitigation, and documents the degree of noise control required. Finally, it summarizes the noise control commitments so they can be incorporated into the final noise control engineering design of the facility.

#### 6.1.2 PROCESS NOISE PREDICTION AND CONTROL

##### Source Characterization

Certain noise sources such as the gas turbine generator and large compressors are loud enough to be very audible off-site, without noise abatement. Numerous other sources are significant because of the accumulative effect of a large number of secondary sources. At this point in the plant's conceptual design, detailed information about building ventilation opening size and location, and make and model of equipment, is not always available. Thus sound levels typical of the equipment to be used were incorporated into the analysis.

The sound level predictions were made as follows. Nine major noise sources locations were identified on the plot plan, each representing a process or building of the plant, as listed in Table D-10. A spread sheet was prepared for each source location which tabulated and summed the sound power levels of each contributing source at that location. Each spread sheet then calculated the total octave band sound pressure level and A-weighted sound level contribution of that source location for each community location.

The design goal of this analysis was to keep the expected plant sound level equal to, or less than, the existing nighttime residual ambient sound level of 39 dBA at Point Shirley (MWRA 1986). This goal was achieved and adopted as the acoustical design criteria for the operating facility.

TABLE D-10

SUMMARY OF PRIMARY NOISE PRODUCING EQUIPMENT  
FOR THE DEER ISLAND TREATMENT FACILITY

SOURCE	DISTANCE(1)	NOISE	SOURCE
1. North pumping station (in)	2250	10 @ 2000 hp electric motor pump drives (with open roll door) existing pump station	
Power facility (ex)		2 @ 6000 kw diesel generators 25 mw gas turbine, cogeneration boiler 13.5 kva transformer	
2. Winthrop (in)	2480	4 @ 125 hp motor pump drives terminal 6 @ 600 hp waste water pumps (4 operate)	
3. Stacked 2nd Clarifiers (in)	2920	20 @ 300 hp RAS pumps 20 @ 7.5 hp WAS pumps 16 @ 40 hp scum pumps 144 @ .5 hp sludge collectors 8 @ 150 hp blowers	(12 operate) (12 operate) (8 operate)  (4 operate)
5. Aeration (ex) Battery C and D	3420	6 @ 150 hp mechanical aerator motors 18 @ 100 hp mechanical aerator motors 16 @ 20 hp selector mixers 2 @ 75 hp 14,000 cfm fans 4 @ 50 hp purge blowers 4 @ 20 hp 500 cfm blowers	   (1 operates) (op. 2/mo.) (2 operate)
7. Aeration (ex) Battery A and B	3780	6 @ 150 hp mechanical aerator motors 18 @ 100 hp mechanical aerator motors 16 @ 20 hp selector mixers 2 @ 75 hp 16400 cfm fans 4 @ 50 hp purge blowers 4 @ 20 hp 500 cfm blowers	   (1 operates) (op. 2/mo.) (2 operate)
9. Oxygen prod.in	4420	2 @ 3500 hp compressors 2 @ 2500 hp compressors 2 on 2-4 days/yr 4 @ 15 hp cooling water pumps (1 operates) reversing valves	(1 op. except)
10. Primary clarifiers (in)	3700	40 @ 7.5 hp sludge pumps 8 @ 40 hp scum pumps 96 @ .5 hp sludge collector drives	(24 operate) (4 operate)

		8 @ 150 hp 1600 cfm blowers (4 operate)
		2 @ 150 hp 32,600 cfm blowers (1 operates)
		1 @ 100 hp 22,100 cfm blower (1 operates)
		2 @ 100 hp 19,000 cfm blowers (1 operates)
11. South Pump station (in)	4200	4 @ 1250 hp electric motor pump station 32 @ 5 hp electric motor slurry pump drives (21 operate) blowers
12. Rollon-rolloff pier (ex)	3800	2 @ 40 hp motor pump drive (standard sound levels)

(1) Distance to nearest neighbor, Point Shirley, Winthrop.

Note (in) means interior- source enclosed in building

(ex) means exterior- source outside.

Where noise mitigation was found to be required, it was incorporated into the predictions using proven noise abatement methodologies. The attenuation of the silencers was, for instance, taken from catalogues. The transmission loss of building materials was based on field data or laboratory test data.

It is understood that the final design of the facility may have minor differences from the conceptual design used in this report, but the acoustical requirements will have been set forth, and mitigation measures will be modified to accommodate the changes. Sometimes community noise predictions of this complexity are made with computer programs which predict far field sound level contours based on the source sound power levels and locations. This black box approach has certain advantages in terms of ease of use, but in order to promote an open understanding of the methodologies used and to facilitate independent review of the predictions, these noise predictions have been made by computer using a spreadsheet format. All assumptions and distances used in the calculation are thus visible, and review and checking of the methodology is straight forward.

The following paragraphs discuss the methodologies used for the noise predictions. The sound power levels so derived are given in Table D-11.

#### Compressors

Compressor intake and casing sound power levels were estimated with the methodology given in EEI, 1978. It was assumed for this analysis that the exhaust noise is controlled by the piping and insulation.

#### Pumps

Pump noise predictions were based upon Miller, 1981.

#### Motors

Motor noise was estimated based on motor horse power, type of motor and need for noise control. Typical sound power levels for motors as rated by the National Electrical Manufacturers Association (NEMA) for motors of standard and quiet design were taken from Harris, 1979. Where motors were used outdoors, quiet motors were usually required in the prediction.

#### Building Attenuation

It is assumed that the buildings are enclosed and that ventilation openings or fans are either of limited size and directed southward away from Point Shirley, are silenced, or both. This assumption is made because building ventilation design detail is not performed at this stage of plant design.

TABLE D-11

OCTAVE BAND SOUND POWER LEVELS FOR  
EACH MAJOR SOURCE LOCATION

<u>NOISE SOURCE</u>		OCTAVE BAND SOUND POWER LEVEL							
		Center Frequency in Hertz							
		<u>63</u>	<u>125</u>	<u>250</u>	<u>500</u>	<u>1K</u>	<u>2K</u>	<u>4K</u>	<u>8K</u>
1.	North pumping station Power facility	100	100	98	103	90	84	80	77
2.	Winthrop terminal	98	97	93	76	66	55	51	49
3.	Stacked 2nd Clarifiers	102	98	94	87	81	72	68	63
5.	Aerators	83	87	89	88	84	78	74	72
7.	Aerators	83	87	89	88	84	78	74	72
9.	Oxygen facility	103	99	94	91	85	96	79	87
10.	Primary clarifiers	98	94	88	85	83	67	66	64
11.	South Pump station	98	96	91	89	83	67	66	64
12.	Roll/on-roll/off pier	94	96	98	98	100	96	92	87



Buildings are assumed to be constructed of brick and acoustical block, unless otherwise noted. This reduces the reverberant interior sound level minimizing occupational exposure to noise within the building and lower sound levels in the community. The calculation indicates that for most of the buildings complete silencing of the ventilation is not required, and that when detailed engineering of the ventilation and interior acoustical treatment of the system is performed an additional 5 to 10 dB of noise emission may be allowed from some of the buildings. This extra noise allowance for a building can be used by either relaxing the requirement for full acoustic treatment on the interior, or by allowing unsilenced ventilation.

### Oxygen Production

Sources of noise associated with the oxygen production are the cryogenic compressors, reversing valves and compressor discharge valves. The compressor intake and casing noise is predicted in the same manner as the other compressors at the plant. Only one of the four compressors operate at the same time, except during plant turnaround.

The cryogenic plant has been designed with molecular sieve prepurifiers rather than the noisier reverse heat exchanger. The prepurifiers remove carbon dioxide and water vapor from the incoming air by adsorption onto a crystalline medium. To avoid clogging, the sieve is purified with nitrogen gas. With prepurification, the switch valves for purging nitrogen operate briefly only once every 8 to 12 hours, rather than the 10-minute frequency required for the reversing heat exchangers. The compressor discharge valves periodically discharge gas to atmosphere when pressure exceeds system requirements.

Sound levels have been measured from the reversing valves at two cryogenic plants which use the reversing heat exchanger. The measured levels were 90 dBA at 15 feet and 104 dBA at 10 feet respectively, from the cryogenic tower. The 104 dBA valve is extremely loud, and if unattenuated, would contribute a sound level of up to 50 dBA in the community (not taking into consideration the effect of atmospheric absorption).

The compressor discharge valves and switch valves and associated piping noise will therefore be reduced 20 to 30 dBA through the use of quiet design valves or acoustical pipe insulation, as necessary. Gas vent silencers are readily available to give 30 or more dBA noise reduction for the compressors discharge valves. The compressor intakes will be silenced.

### Gas Turbine

The gas turbine used for power generation is potentially a source of off-site noise. The dominate noise components are the combustion air intake and exhaust. Additional significant sources include casing radiated noise, gas compressor noise, and air filter pulse cleaning, if used. The co-generation capability includes sources of noise such as bypass exhaust, generator, heat exchanger sidewall noise, as well as forced draft fan noise, if auxiliary boiler firing is utilized. The transformer associated with the power generation is also a source of noise.

The primary means for controlling gas turbine noise is to enclose the turbine generator inside an acoustically treated building or enclosure, as well as the use of large intake and exhaust silencers. The high frequency compressor noise from the intake is relatively easy to attenuate. Special care must be utilized, however, to attenuate the low frequency combustion noise from the compressor exhaust. In particular, attention must be given to noise in the 31 Hz octave band which, while having little effect on the A-weighted sound level, can vibrate windows and structures if not appropriately mitigated.

A gas turbine with standard silencing is approximately 65 dBA at 400 ft, the standard NEMA (National Electrical Manufacturers Association) distance for measuring gas turbines. This is roughly equivalent to 50 dBA at Point Shirley, which is excessively loud. Approximately 15 dBA of additional noise reduction over standard is therefore required to bring the sound level down to approximately 35 dBA or less at Point Shirley. This corresponds to a NEMA 400-ft sound level of 50 dBA or less.

The state-of-the-art sound level design for gas turbine noise control in the U.S. is approximately 45 dBA at 400 ft for 50 MW gas turbines, so the level of noise control required is attainable. There are several gas turbine installations in this country with NEMA levels of 45 dBA. However a considerable engineering effort is required to achieve this low sound level. It is not usually possible to get information, only quotes, on very quiet units.

For the purposes of this report it is therefore specified that the gas turbine co-generation unit and its auxiliaries will be required to meet a NEMA sound level of 50 dBA or quieter at 400 ft, as well as specific octave band requirements which will prevent low frequency annoyance.

### Diesel Generators

Sound pressure level data for the new fast-track 6000-kw diesels is based upon manufacturer's data. The existing Nordberg diesel pump drives are not included in the estimate because they are being replaced with electric motor drives (which are included).

## 6.1.3 RESULTS

Sound pressure levels were predicted using the sound power level derived as discussed above. Sound level estimates were made for each of the noise monitoring locations (MWRA 1986). The results of the predictions for the nearest neighbor on Point Shirley are given in Table D-12. As can be seen from Table D-12 the total sound level at the nearest neighbor is expected to be approximately 36 dBA. This is 3 dBA lower than the residual ambient sound levels measured in the area and will cause a less than 2 dBA increase in the existing ambient sound level under the most favorable noise propagating conditions. This change in ambient sound level will not be noticeable. Most of the time the plant will not be upwind of the community, and the sound levels will be substantially lower because of the landforms and wind shadows.

TABLE D-12

**SOUND LEVEL CONTRIBUTION OF EACH NOISE SOURCE  
AT THE NEAREST NEIGHBOR ON POINT SHIRLEY**

LOCATION	SOUND LEVEL CONTRIBUTION, dBA
1. North pumping station Power facility	35
2. Winthrop terminal	12
3. Stacked 2nd Clarifiers	22
5. Aeration	18
7. Aeration	17
9. Oxygen facility	20
10. Primary clarifiers	15
11. South Pump station	16
12. Roll/on-roll/off pier	28
TOTAL	36

The projections indicate that the most dominant noise sources are the gas turbine, the existing pump station open door, and the roll-on/roll-off pier pump. It is not known at this time who will own and control the pier pumps, (they may be on a ship), so no noise mitigation was assumed in the prediction. The sound level contribution of the other individual sources is relatively minor.

The sound level of each of the sources appears to be very low when considered individually. However, there is not as much allowance for excess noise as may appear. For instance, the seven quietest sources, when grouped together, totaled 27 dBA. If each of these sources were 5 dBA louder, their total would be 32 dB, which, when added to the 35 dBA from power generation, would give 37 dBA. If they were each raised by 10 dB, the total would be 40 dBA. It can thus be concluded that an additional 5 dB can be allowed for building ventilation or other miscellaneous sources without impacting the site criteria of 39 dBA.

The proper acoustical design for building ventilation systems is an important part of the plant noise mitigation. For instance, for a building one hundred feet square, the sound coming from an opening in the wall of one yd<sup>2</sup> facing the residential area would exceed that coming through the walls of the balance of the building. If that opening were on the south side of the building, however, it could be perhaps 20 times bigger before it had the same impact on building noise. Also, if sound-absorbing material does not cover the entire interior of the building, there will be a reverberant buildup of noise which will, in turn, increase the exterior sound level of the buildings.

The acoustical design of all the buildings will have to be handled with considerable care to assure that all the necessary equipment is purchased at the appropriate sound level and is properly enclosed. Attention will have to be given to the location and size of building openings such as roll doors, ventilation louvers, ventilation fans, etc. It is equally important that all exterior motors be purchased at the appropriate low noise level and that fans and blowers be silenced as required.

## 6.2 NUT ISLAND OPERATIONAL NOISE

The new headworks facility will provide preliminary treatment to the South System flows prior to conveyance to Deer Island. The screenings building will contain equipment for screening and grit removal but will not contain much large, loud equipment. It will be fully enclosed and the sound levels at the nearest residential area are expected to be less than 25 dBA.

The daytime residual ambient sound levels have been approximately 50 dBA on Nut Island. The nighttime ambient sound level has not been measured, but it would be expected to be approximate 30 to 35 dBA or greater. The screenings building noise will therefore not be audible at the nearest residential area.

## 7.0 NOISE CONTROL ENGINEERING

### 7.1 INTRODUCTION

The detailed design and construction of the project will take a number of years to engineer. During that time hundreds of noise mitigation tasks will have to be performed at the appropriate time and in the right sequence to meet the required interior and exterior noise goals. Dozens of pieces of equipment will have to be purchased to maintain an appropriate sound level. Noise mitigation equipment such as silencers will have to be specified and purchased.

In order to achieve these goals a systematic approach to noise control engineering is required. The approach should be sufficiently organized to accommodate problems such as job delays, changes in staff, and changes in facility design. This section outlines the recommended key elements of the engineering effort and tasks to be performed by a noise control engineer in order to achieve the required results.

The key operating philosophy for success is that the noise control engineer (NCE) assumes complete responsibility for the facility noise control engineering. This means that he actively initiates participation in all the required project interaction including specifications, bid review, installation, etc.

### 7.2 NOISE CONTROL PLAN ELEMENTS

The key elements to be included in the noise control engineering effort are as follows:

#### 7.2.1 ACOUSTICAL MODEL

An acoustical model should be developed which includes the sound power level of all major sources, the anticipated noise reduction for each source, and the total sound level at the nearest neighbors. This model not only confirms the total facility sound level at the nearest neighbor, but also gives the individual allowable contribution of each source.

#### 7.2.2 PROJECT TRACKING SYSTEM

The NCE must develop a system which allows tracking of all noise control activities associated with the project. This system should continuously provide for each item of equipment, the status and required task dates for noise criteria development, noise specification insert, comparison of bids, noise control requirement decision, noise control engineering, incorporation of recommendations into project design, and purchase of noise control hardware. This system will provide for the timely integration of noise control engineering into the project, and will allow the status of the project to be assessed at all times.



### 7.2.3 ACOUSTICAL CRITERIA

The allowable sound level for each significant contributor to community sound level should be defined from the computer model for input in the bid and purchase specifications.

### 7.2.4 NOISE SPECIFICATION PREPARATION AND INPUT

The noise specification must be specific for each piece of noisy equipment being purchased, specify the appropriate noise levels, realistically reflect the capability of the industry to quiet equipment, and be inserted into the bid purchase specification in a timely manner.

### 7.2.5 COMPARISON OF BIDS

The purchase bids on major noise sources must be evaluated for conformance with noise requirements. Often bids do not provide the information requested and judgements and interpretations are required. Discussions with suppliers and vendors may be necessary to resolve problems.

### 7.2.6 NOISE CONTROL ENGINEERING

Where suitably quiet equipment cannot be purchased, noise mitigation must be added as appropriate. This may include silencers, acoustical pipe lagging, architectural treatment, enclosures, etc. These items must also be purchased and installed correctly.

### 7.2.7 COMMITMENT TRACKING

When noise control recommendations are made, the recommendations must be tracked to ensure that they are incorporated into the project design. Where the initial recommendations are not feasible, alternate recommendations must be made.

## 7.3 NOISE MONITORING PROGRAM

It is recommended that construction and operational noise be monitored to assure compliance with the site design criteria. The construction noise will be highly dependent upon wind direction, but will, on occasion, be sufficiently loud to measure with continuous monitors. However, because of the other noise sources in the area, any construction noise audible off-site will be mixed with aircraft and other noise, so considerable attention must be given to interpretation of the data.

Both staffed and unstaffed surveys of construction noise should be conducted periodically or continuously to determine compliance with the anticipated levels and to determine if excessive noise is being created by any unusual process which can be controlled. In addition, a construction noise hot-line should be established for neighbors to register complaints. Complaints should then be investigated to determine if alternate construction approaches can be



taken to mitigate the noise.

The plant operation should not be loud enough to contribute significantly to noise levels off-site. However, after plant startup, a noise survey should be taken to measure the sound level of major sources to determine if they are as quiet as anticipated, especially where a premium has been paid to purchase quiet equipment. Measurement should also be made at various locations between the plant and the nearest neighbors. These measurements should be made at night during periods when the wind has a SE component.

## 8.0 REFERENCES

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**ATTACHMENT D-1**

**STATISTICAL AMBIENT SOUND LEVELS  
POINT SHIRLEY, WINTHROP, MA**

Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
01-Sep	17	63.5	56.5	51.5
01-Sep	18	63.0	56.5	51.5
01-Sep	19	62.5	56.5	51.0
01-Sep	20	62.0	55.0	50.0
01-Sep	21	66.0	58.0	50.5
01-Sep	22	66.0	51.0	46.5
01-Sep	23	59.0	47.5	44.5
01-Sep	24	52.0	44.0	42.5
02-Sep	1	54.0	45.5	42.5
02-Sep	2	48.5	42.5	40.5
02-Sep	3	52.5	42.0	39.0
02-Sep	4	53.0	41.5	38.0
02-Sep	5	51.5	43.0	37.0
02-Sep	6	58.0	44.0	39.0
02-Sep	7	76.5	62.0	47.0
02-Sep	8	70.5	52.0	46.5
02-Sep	9	71.5	54.0	48.5
02-Sep	10	72.0	53.0	48.0
02-Sep	11	72.0	50.0	45.5
02-Sep	12	71.5	51.5	46.5
02-Sep	13	73.5	52.0	47.0
02-Sep	14	67.5	50.0	47.0
02-Sep	15	72.0	50.0	46.0
02-Sep	16	70.5	50.0	44.7
02-Sep	17	73.0	49.0	43.0
02-Sep	18	74.0	51.5	44.0
02-Sep	19	70.0	50.0	45.5
02-Sep	20	70.5	49.0	46.0
02-Sep	21	74.0	51.5	47.5
02-Sep	22	73.0	51.0	46.5
02-Sep	23	71.5	48.5	46.0
02-Sep	24	49.0	46.5	45.5

Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA  
(continued)

	DATE (1986)	TIME	-----dBA-----		
			L10	L50	L90
03-Sep	1	47.5	45.5	44.5	
	03-Sep	2	46.0	44.5	43.5
	03-Sep	3	45.0	44.0	43.0
	03-Sep	4	44.5	43.0	42.0
	03-Sep	5	44.0	42.5	41.5
	03-Sep	6	58.5	45.0	42.5
	03-Sep	7	76.5	55.0	45.5
	03-Sep	8	74.0	53.5	46.0
	03-Sep	9	75.0	55.5	46.5
	03-Sep	10	66.5	48.5	45.5
	03-Sep	11	73.0	51.0	45.5
	03-Sep	12	73.0	50.0	44.0
	03-Sep	13	77.5	54.5	46.0
	03-Sep	14	68.5	47.5	44.0
	03-Sep	15	77.5	51.5	44.5
	03-Sep	16	73.0	52.0	44.5
	03-Sep	17	77.5	54.0	44.0
	03-Sep	18	77.5	55.0	45.0
	03-Sep	19	77.5	58.0	45.5
	03-Sep	20	71.0	49.0	44.0
	03-Sep	21	73.5	52.0	43.5
	03-Sep	22	70.5	45.5	42.0
	03-Sep	23	58.0	42.5	39.5
	03-Sep	24	47.0	40.0	38.0
	04-Sep	1	47.0	39.0	37.5
	04-Sep	2	43.0	37.5	36.0
	04-Sep	3	42.5	36.0	35.0
	04-Sep	4	39.0	36.5	36.0
	04-Sep	5	45.0	42.0	39.0
	04-Sep	6	54.0	46.5	43.5
	04-Sep	7	61.0	55.0	48.5

Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA  
(continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
04-Sep	8	61.0	54.0	48.5
04-Sep	9	62.0	54.0	49.0
04-Sep	10	61.5	52.5	47.5
04-Sep	11	74.5	59.5	41.0
04-Sep	12	74.5	60.0	52.5
04-Sep	13	74.0	56.0	51.5
04-Sep	14			
04-Sep	15	73.0	58.0	52.0
04-Sep	16	71.5	54.0	50.0
04-Sep	17	62.0	56.0	51.0
04-Sep	18	61.0	56.0	50.5
04-Sep	19	62.0	53.5	48.5
04-Sep	20	60.5	53.0	48.0
04-Sep	21	60.5	52.0	46.5
04-Sep	22	61.0	51.0	47.0
04-Sep	23	57.0	47.5	45.0
04-Sep	24	52.0	45.5	44.0
05-Sep	1	54.0	46.5	45.0
05-Sep	2	48.5	44.5	43.0
05-Sep	3	48.0	45.5	44.0
05-Sep	4	51.5	47.5	43.0
05-Sep	5	51.5	47.0	44.0
05-Sep	6	59.0	52.5	48.5
05-Sep	7	65.0	58.5	53.0
05-Sep	8	65.0	58.5	53.0
05-Sep	9	64.0	57.5	53.0
05-Sep	10	62.0	57.0	52.5
05-Sep	11	67.5	59.0	53.5
05-Sep	12	75.0	59.0	51.5
05-Sep	13	71.0	56.0	53.0
05-Sep	14	64.5	57.0	52.0



Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA  
(continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
05-Sep	15	62.5	55.5	52.0
05-Sep	16	63.5	57.0	51.5
05-Sep	17	62.0	56.5	51.0
05-Sep	18	62.0	55.5	49.0
05-Sep	19	61.5	55.5	49.5
05-Sep	20	63.0	56.0	47.0
05-Sep	21	63.0	54.5	48.5
05-Sep	22	59.5	49.5	46.5
05-Sep	23	53.5	45.5	43.0
05-Sep	24	44.5	42.5	42.0
06-Sep	1	44.0	42.0	41.0
06-Sep	2	44.5	42.5	41.5
06-Sep	3	44.0	42.0	40.5
06-Sep	4	45.0	42.5	41.0
06-Sep	5	47.5	43.0	41.5
06-Sep	6	56.5	49.0	46.0
06-Sep	7	62.0	53.0	46.0
06-Sep	8	61.5	53.5	42.5
06-Sep	9	62.0	53.0	45.0
06-Sep	10	61.5	55.5	50.0
06-Sep	11	69.0	58.0	51.0
06-Sep	12	74.0	58.0	53.0
06-Sep	13	68.0	57.0	53.0
06-Sep	14	70.0	57.5	53.0
06-Sep	15	71.0	59.5	55.5
06-Sep	16	74.0	59.5	54.5
06-Sep	17	63.0	57.0	51.5
06-Sep	18	61.0	54.5	49.0
06-Sep	19	61.5	54.5	49.0
06-Sep	20	60.0	53.5	46.0
06-Sep	21	60.0	52.5	46.0

Statistical Ambient Sound Levels  
 Position 1: Engineer's House  
 Point Shirley, Winthrop, MA  
 (continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
06-Sep	22	62.0	52.0	47.5
06-Sep	23	55.0	48.0	46.5
06-Sep	24	50.0	48.0	46.5
07-Sep	1	50.0	48.5	47.0
07-Sep	2	49.5	47.5	47.0
07-Sep	3	50.0	47.0	45.0
07-Sep	4	48.0	47.0	46.0
07-Sep	5	50.5	47.5	46.5
07-Sep	6	67.5	53.5	49.5
07-Sep	7	70.5	61.5	55.0
07-Sep	8	63.0	56.5	50.0
07-Sep	9	64.5	58.0	51.0
07-Sep	10	61.0	53.0	47.0
07-Sep	11	61.5	54.0	47.0
07-Sep	12	60.0	53.0	47.0
07-Sep	13	60.0	51.5	46.5
07-Sep	14	60.0	52.0	47.5
07-Sep	15	59.0	52.5	48.5
07-Sep	16	61.0	55.0	49.5
07-Sep	17	60.0	54.0	48.0
07-Sep	18	62.5	57.0	50.5
07-Sep	19	59.5	53.5	48.0
07-Sep	20	65.0	54.0	46.5
07-Sep	21	66.5	56.0	46.5
07-Sep	22	68.5	57.5	48.5
07-Sep	23	59.5	50.5	48.0
07-Sep	24	55.5	48.5	46.0
08-Sep	1	58.0	47.0	45.0
08-Sep	2	50.5	46.0	44.5
08-Sep	3	50.0	47.5	45.5
08-Sep	4	48.0	45.5	44.0

Statistical Ambient Sound Levels  
 Position 1: Engineer's House  
 Point Shirley, Winthrop, MA  
 (continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
08-Sep	5	53.5	48.0	46.0
08-Sep	6	62.5	54.5	51.0
08-Sep	7	68.0	60.5	55.5
08-Sep	8	66.5	59.5	53.5
08-Sep	9	67.5	60.5	53.0
08-Sep	10	63.0	52.5	46.0
08-Sep	11	62.0	56.0	48.5
08-Sep	12	64.5	56.5	50.5
08-Sep	13	61.0	54.5	49.5
08-Sep	14	62.5	55.5	51.0
08-Sep	15	62.0	55.0	50.5
08-Sep	16	63.0	56.0	51.0
08-Sep	17	63.5	56.5	51.0
08-Sep	18	65.6	56.5	52.5
08-Sep	19	65.0	58.5	53.0
08-Sep	20	65.0	58.5	52.0
08-Sep	21	67.0	56.5	49.0
08-Sep	22	66.0	56.5	51.0
08-Sep	23	61.0	50.0	48.5
08-Sep	24	53.0	51.0	49.0
09-Sep	1	62.5	51.5	49.5
09-Sep	2	53.0	49.5	47.5
09-Sep	3	49.0	47.0	45.5
09-Sep	4	49.0	47.0	46.0
09-Sep	5	51.5	47.5	46.5
09-Sep	6	64.0	54.5	51.5
09-Sep	7	67.5	61.5	55.0
09-Sep	8	66.5	60.0	56.0
09-Sep	9	65.0	58.5	54.5
09-Sep	10	60.5	53.5	49.0
09-Sep	11	61.0	54.5	50.0

Statistical Ambient Sound Levels  
 Position 1: Engineer's House  
 Point Shirley, Winthrop, MA  
 (continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
09-Sep	12	61.5	55.5	52.0
09-Sep	13	59.5	54.5	51.0
09-Sep	14	60.0	54.5	52.0
09-Sep	15	61.5	56.0	53.0
09-Sep	16	63.0	58.5	56.0
09-Sep	17	64.0	60.0	57.5
09-Sep	18	63.5	60.0	58.0
09-Sep	19	64.0	58.5	56.0
09-Sep	20	63.5	57.0	54.0
09-Sep	21	65.0	55.0	51.5
09-Sep	22	67.0	51.5	49.0
09-Sep	23	56.0	51.5	49.5
09-Sep	24	56.0	54.5	53.0
10-Sep	1	58.5	57.0	55.5
10-Sep	2	58.5	57.0	56.0
10-Sep	3	58.5	57.0	55.0
10-Sep	4	58.0	56.0	55.0
10-Sep	5	58.0	56.0	54.5
10-Sep	6	62.5	56.5	55.0
10-Sep	7	65.0	59.5	56.5
10-Sep	8	64.5	59.5	57.5
10-Sep	9	64.0	59.0	56.5
10-Sep	10	62.0	57.0	55.5
10-Sep	11	62.5	59.0	56.0
10-Sep	12	63.0	60.0	59.0
10-Sep	13	63.0	60.5	59.0
10-Sep	14	64.0	62.0	60.0
10-Sep	15	63.5	60.5	58.5
10-Sep	16	64.0	60.5	58.5
10-Sep	17	64.0	60.5	58.0
10-Sep	18	64.5	60.5	58.0

Statistical Ambient Sound Levels  
 Position 1: Engineer's House  
 Point Shirley, Winthrop, MA  
 (continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
10-Sep	19	64.5	60.0	57.5
10-Sep	20	64.5	58.5	56.0
10-Sep	21	65.0	58.5	56.0
10-Sep	22	63.0	56.5	54.0
10-Sep	23	59.0	54.0	52.0
10-Sep	24	57.5	56.0	54.5
11-Sep	1	59.0	58.0	56.5
11-Sep	2	58.5	57.5	56.5
11-Sep	3	59.5	58.0	57.0
11-Sep	4	58.0	57.0	56.0
11-Sep	5	58.5	57.0	55.5
11-Sep	6	61.0	56.5	54.5
11-Sep	7	64.5	60.5	58.0
11-Sep	8	65.0	61.0	59.5
11-Sep	9	65.0	61.0	59.5
11-Sep	10	63.5	60.0	58.0
11-Sep	11	64.0	60.0	57.5
11-Sep	12	63.5	58.5	56.5
11-Sep	13	64.5	60.0	58.0
11-Sep	14	62.5	59.5	58.0
11-Sep	15	63.0	59.0	57.0
11-Sep	16	63.5	59.0	56.5
11-Sep	17	64.0	58.0	55.0
11-Sep	18	64.0	58.5	56.0
11-Sep	19	68.0	60.0	56.0
11-Sep	20	65.0	58.0	53.5
11-Sep	21	66.0	60.0	54.5
11-Sep	22	65.5	59.5	53.0
11-Sep	23	64.5	55.0	51.5
11-Sep	24	56.5	52.5	51.5
12-Sep	1	57.0	54.0	52.5

Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA  
(continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
12-Sep	2	53.0	51.5	50.5
12-Sep	3	52.0	51.0	50.0
12-Sep	4	53.0	51.5	50.5
12-Sep	5	52.0	50.0	47.5
12-Sep	6	67.0	51.5	47.5
12-Sep	7	77.0	62.0	54.5
12-Sep	8	74.0	60.0	50.0
12-Sep	9	72.0	60.0	54.0
12-Sep	10	67.5	56.0	50.0
12-Sep	11	74.0	58.5	51.0
12-Sep	12	76.0	59.0	50.0
12-Sep	13	67.0	55.0	50.0
12-Sep	14	70.5	56.5	50.5
12-Sep	15	70.5	57.5	53.0
12-Sep	16	63.5	57.0	53.0
12-Sep	17	62.5	56.5	52.5
12-Sep	18	63.5	57.0	52.5
12-Sep	19	63.0	56.0	51.0
12-Sep	20	65.0	57.0	50.5
12-Sep	21	64.0	55.0	53.0
12-Sep	22	59.5	55.5	54.0
12-Sep	23	57.0	54.0	51.5
12-Sep	24	51.0	49.5	49.0
13-Sep	1	51.0	48.5	47.0
13-Sep	2	49.5	45.5	42.0
13-Sep	3	43.0	41.0	39.0
13-Sep	4	47.0	41.5	39.5
13-Sep	5	48.5	46.5	45.5
13-Sep	6	64.0	48.0	45.5
13-Sep	7	70.5	56.5	49.0
13-Sep	8	71.5	57.0	47.0



Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA  
(continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
13-Sep	9	73.0	57.0	51.0
13-Sep	10	67.5	54.5	49.5
13-Sep	11	73.5	59.0	51.0
14-Sep	12	71.0	59.5	52.5
14-Sep	13	62.5	55.5	51.5
14-Sep	14	64.5	58.0	51.5
14-Sep	15	60.5	53.5	48.5
14-Sep	16	61.5	54.0	47.0
14-Sep	17	62.5	55.0	46.5
14-Sep	18	61.0	53.5	46.0
14-Sep	19	62.5	54.5	47.5
14-Sep	20	62.5	52.5	45.0
14-Sep	21	60.5	51.5	42.0
14-Sep	22	60.5	50.0	42.5
14-Sep	23	56.5	45.5	40.0
14-Sep	24	52.5	41.0	39.5
15-Sep	1	47.0	44.0	42.0
15-Sep	2	43.0	41.5	40.0
15-Sep	3	56.5	46.5	42.0
15-Sep	4	54.5	48.5	43.5
15-Sep	5	88.5	52.5	45.0
15-Sep	6	76.0	57.5	46.0
15-Sep	7	82.0	62.0	54.0
15-Sep	8	82.0	63.5	52.5
15-Sep	9	71.0	60.0	51.5
15-Sep	10	69.5	58.5	51.5
15-Sep	11	70.0	59.5	53.0
15-Sep	12	70.0	60.5	53.0
15-Sep	13	71.5	59.0	52.0
15-Sep	14	68.0	59.0	52.5
15-Sep	15	72.5	62.0	54.5

Statistical Ambient Sound Levels  
Position 1: Engineer's House  
Point Shirley, Winthrop, MA  
(continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
15-Sep	16	71.5	61.5	55.0
15-Sep	17	73.0	62.5	56.5
15-Sep	18	72.0	61.0	55.0
15-Sep	19	72.5	60.0	54.5
15-Sep	20	67.0	57.0	50.5
15-Sep	21	66.0	56.0	49.5
15-Sep	22	55.0	54.5	49.5
15-Sep	23	59.0	52.0	49.0
15-Sep	24	56.5	50.0	47.5
16-Sep	1	53.5	49.0	46.5
16-Sep	2	55.0	49.0	46.5
16-Sep	3	49.5	44.5	43.0
16-Sep	4	48.0	45.0	43.5
16-Sep	5	47.5	45.0	44.0
16-Sep	6	65.0	51.0	46.5
16-Sep	7	69.5	57.5	50.5
16-Sep	8	68.5	57.5	50.0
16-Sep	9	68.0	56.5	49.0
16-Sep	10	62.0	54.5	44.0
16-Sep	11	65.0	55.0	45.5
16-Sep	12	65.5	53.5	45.0
16-Sep	13	61.5	49.0	43.5
16-Sep	14	69.5	48.5	44.5
16-Sep	15	72.0	50.0	44.5
16-Sep	16	74.0	53.0	47.5
16-Sep	17	77.0	55.5	47.0
16-Sep	18	78.0	56.0	50.0
16-Sep	19	76.5	53.5	48.0
16-Sep	20	56.5	48.0	44.0
16-Sep	21	60.5	50.0	43.0
16-Sep	22	59.0	48.0	42.0

Statistical Ambient Sound Levels  
 Position 1: Engineer's House  
 Point Shirley, Winthrop, MA  
 (continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
16-Sep	23	57.0	43.5	41.0
16-Sep	24	46.5	41.5	40.0
17-Sep	1	48.5	40.0	38.5
17-Sep	2	48.0	44.0	39.0
17-Sep	3	43.0	39.5	38.5
17-Sep	4	41.5	39.5	38.5
17-Sep	5	51.5	44.5	39.5
17-Sep	6	62.0	50.0	44.0
17-Sep	7	64.5	59.0	53.5
17-Sep	8	64.5	59.0	54.0
17-Sep	9	62.5	56.0	50.5
17-Sep	10	60.0	54.0	48.5
17-Sep	11	61.0	54.0	47.5
17-Sep	12	61.0	54.0	49.0
17-Sep	13	58.5	52.0	47.0
17-Sep	14	58.5	52.0	48.5
17-Sep	15	59.5	53.0	50.0
17-Sep	16	59.0	53.0	50.0
17-Sep	17	61.5	54.5	50.5
17-Sep	18	62.0	55.0	49.5
17-Sep	19	62.0	55.5	51.0
17-Sep	20	61.0	55.5	50.0
17-Sep	21	62.5	53.5	48.5
17-Sep	22	62.0	52.0	45.0
17-Sep	23	56.5	48.0	44.5
17-Sep	24	56.5	47.5	42.5
18-Sep	1	51.0	47.5	44.0
18-Sep	2	49.5	47.5	46.5
18-Sep	3	48.5	47.5	46.0
18-Sep	4	52.0	49.0	43.5
18-Sep	5	50.5	46.0	42.5

Statistical Ambient Sound Levels  
 Position 1: Engineer's House  
 Point Shirley, Winthrop, MA  
 (continued)

DATE (1986)	TIME	-----dBA-----		
		L10	L50	L90
18-Sep	6	59.5	49.5	45.0
18-Sep	7	63.5	57.0	50.5
18-Sep	8	64.0	57.0	51.5
18-Sep	9	61.5	54.5	48.0
18-Sep	10	60.0	50.0	45.0
18-Sep	11	62.0	54.0	46.0

**ATTACHMENT D-2**

**ATMOSPHERIC ABSORPTION COEFFICIENTS**

AMERICAN NATIONAL STANDARD  
ATMOSPHERIC ABSORPTION COEFFICIENTS

TABLE . Absorption coefficient for pure tones in  $[dB(100m)^{-1}]$  at a pressure of 1 atm. [For computational convenience all entries have been rounded to the nearest 0.01 dB (100 m) $^{-1}$ .]

(a) Temperature = 0.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
63	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
80	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
100	0.07	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
125	0.10	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.03
160	0.15	0.10	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05
200	0.21	0.14	0.10	0.08	0.07	0.06	0.06	0.06	0.06	0.06
250	0.31	0.20	0.15	0.10	0.09	0.08	0.08	0.08	0.08	0.08
315	0.46	0.31	0.22	0.14	0.12	0.10	0.10	0.10	0.10	0.10
400	0.66	0.46	0.34	0.21	0.16	0.14	0.13	0.12	0.12	0.12
500	0.89	0.68	0.50	0.31	0.23	0.19	0.17	0.16	0.15	0.14
630	1.17	0.98	0.75	0.47	0.34	0.27	0.23	0.21	0.20	0.18
800	1.46	1.38	1.12	0.72	0.52	0.40	0.34	0.30	0.27	0.24
1000	1.72	1.83	1.59	1.08	0.77	0.60	0.49	0.42	0.38	0.32
1250	1.94	2.32	2.19	1.59	1.16	0.89	0.73	0.62	0.54	0.45
1600	2.14	2.85	2.96	2.39	1.80	1.40	1.14	0.96	0.83	0.67
2000	2.29	3.29	3.71	3.35	2.65	2.10	1.71	1.44	1.24	0.99
2500	2.40	3.65	4.44	4.54	3.82	3.11	2.57	2.17	1.87	1.48
3150	2.52	3.97	5.13	5.93	5.41	4.60	3.88	3.31	2.87	2.26
4000	2.65	4.25	5.73	7.42	7.43	6.69	5.83	5.06	4.43	3.52
5000	2.82	4.51	6.22	8.75	9.55	9.16	8.31	7.40	6.58	5.31
6300	3.06	4.82	6.70	10.01	11.81	12.13	11.57	10.67	9.72	8.04
8000	3.44	5.25	7.26	11.19	14.06	15.44	15.59	15.01	14.10	12.13
10000	4.01	5.84	7.92	12.29	16.05	18.54	19.69	19.80	19.26	17.36

(b) Temperature = 5.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
63	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
80	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01
100	0.06	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02
125	0.08	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03
160	0.11	0.08	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05
200	0.16	0.11	0.09	0.08	0.07	0.07	0.07	0.07	0.07	0.06
250	0.24	0.16	0.12	0.10	0.09	0.09	0.09	0.09	0.09	0.09
315	0.36	0.23	0.17	0.13	0.12	0.11	0.11	0.11	0.11	0.11
400	0.54	0.35	0.25	0.18	0.15	0.14	0.14	0.14	0.14	0.14
500	0.78	0.51	0.37	0.24	0.20	0.18	0.17	0.17	0.17	0.17
630	1.12	0.77	0.55	0.35	0.27	0.24	0.22	0.21	0.21	0.21
800	1.57	1.16	0.85	0.53	0.40	0.33	0.29	0.28	0.27	0.26
1000	2.05	1.67	1.26	0.79	0.58	0.47	0.40	0.37	0.34	0.33
1250	2.55	2.33	1.85	1.18	0.85	0.67	0.57	0.51	0.46	0.42
1600	3.09	3.23	2.75	1.85	1.33	1.04	0.86	0.75	0.67	0.58
2000	3.51	4.13	3.82	2.74	2.00	1.56	1.28	1.10	0.97	0.82
2500	3.86	5.05	5.10	3.99	3.00	2.35	1.93	1.64	1.44	1.18
3150	4.16	5.93	6.55	5.73	4.50	3.58	2.95	2.50	2.18	1.76
4 000	4.43	6.72	8.06	8.02	6.71	5.49	4.56	3.89	3.39	2.72
5000	4.68	7.35	9.37	10.51	9.46	8.03	6.81	5.86	5.12	4.10
6300	4.98	7.95	10.58	13.26	13.00	11.62	10.14	8.86	7.82	6.31
8000	5.41	8.59	11.72	16.08	17.23	16.41	14.91	13.35	11.97	9.80
10000	6.00	9.31	12.78	18.56	21.43	21.74	20.67	19.10	17.48	14.66

FROM "METHOD FOR THE CALCULATION OF THE ABSORPTION OF SOUND BY THE ATMOSPHERE"  
ANSI S1.26-1978



Table continued

(c) Temperature = 10.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00
63	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
80	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01
100	0.05	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
125	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.03
160	0.10	0.08	0.07	0.07	0.07	0.06	0.06	0.05	0.05	0.04
200	0.13	0.10	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.06
250	0.19	0.13	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09
315	0.27	0.18	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.12
400	0.41	0.27	0.21	0.17	0.16	0.16	0.17	0.17	0.17	0.17
500	0.61	0.39	0.29	0.22	0.20	0.20	0.20	0.20	0.21	0.21
630	0.91	0.58	0.42	0.30	0.26	0.24	0.24	0.25	0.25	0.26
800	1.36	0.88	0.64	0.42	0.35	0.32	0.30	0.30	0.31	0.32
1000	1.94	1.31	0.94	0.61	0.48	0.41	0.39	0.38	0.37	0.38
1250	2.66	1.93	1.41	0.89	0.67	0.57	0.51	0.48	0.47	0.46
1600	3.61	2.91	2.19	1.39	1.02	0.83	0.73	0.66	0.63	0.59
2000	4.53	4.08	3.22	2.08	1.52	1.21	1.04	0.92	0.85	0.77
2500	5.42	5.52	4.64	3.12	2.28	1.80	1.51	1.32	1.20	1.05
3150	6.25	7.22	6.57	4.70	3.47	2.74	2.28	1.97	1.76	1.50
4000	6.98	9.03	9.02	7.05	5.36	4.25	3.53	3.03	2.68	2.23
5000	7.56	10.64	11.59	10.05	7.95	6.40	5.33	4.57	4.02	3.30
6300	8.11	12.14	14.33	14.00	11.72	9.68	8.15	7.02	6.17	5.03
8000	8.71	13.53	17.03	18.84	16.99	14.58	12.51	10.88	9.62	7.84
10000	9.41	14.77	19.36	23.76	23.19	20.86	18.38	16.24	14.48	11.89

(d) Temperature = 15.0 °C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
63	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
80	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
100	0.06	0.05	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02
125	0.07	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03	0.02
160	0.09	0.08	0.08	0.08	0.07	0.06	0.06	0.05	0.05	0.04
200	0.12	0.10	0.10	0.10	0.09	0.09	0.08	0.07	0.07	0.06
250	0.16	0.13	0.12	0.13	0.12	0.12	0.11	0.10	0.10	0.08
315	0.22	0.17	0.15	0.15	0.16	0.15	0.15	0.14	0.14	0.12
400	0.32	0.23	0.20	0.19	0.19	0.20	0.20	0.19	0.19	0.18
500	0.47	0.31	0.26	0.23	0.23	0.24	0.24	0.24	0.24	0.24
630	0.70	0.45	0.35	0.29	0.28	0.29	0.29	0.30	0.31	0.31
800	1.06	0.67	0.51	0.38	0.35	0.35	0.36	0.37	0.38	0.39
1000	1.57	0.99	0.73	0.52	0.45	0.43	0.43	0.44	0.45	0.47
1250	2.29	1.48	1.07	0.73	0.60	0.55	0.53	0.53	0.54	0.56
1600	3.39	2.30	1.67	1.09	0.86	0.75	0.70	0.68	0.67	0.68
2000	4.68	3.40	2.49	1.60	1.22	1.04	0.94	0.88	0.85	0.84
2500	6.20	4.92	3.72	2.40	1.79	1.48	1.30	1.19	1.13	1.07
3150	7.90	7.03	5.56	3.65	2.71	2.19	1.88	1.69	1.56	1.42
4000	9.63	9.76	8.24	5.64	4.19	3.36	2.84	2.51	2.28	2.00
5000	11.10	12.69	11.55	8.38	6.30	5.05	4.25	3.71	3.33	2.85
6300	12.44	15.87	15.75	12.42	9.59	7.73	6.50	5.64	5.03	4.22
8000	13.68	19.05	20.68	18.14	14.62	11.97	10.11	8.77	7.79	6.48
10000	14.80	21.81	25.49	24.97	21.24	17.83	15.22	13.27	11.80	9.77

Table continued

(e) Temperature = 20.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
63	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
80	0.05	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
100	0.06	0.06	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.01
125	0.08	0.07	0.07	0.05	0.04	0.04	0.03	0.03	0.02	0.02
160	0.10	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03
200	0.12	0.12	0.12	0.11	0.10	0.08	0.07	0.07	0.06	0.05
250	0.15	0.14	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.07
315	0.20	0.18	0.18	0.18	0.18	0.17	0.16	0.14	0.13	0.11
400	0.27	0.22	0.22	0.22	0.23	0.22	0.22	0.21	0.19	0.17
500	0.38	0.29	0.27	0.27	0.28	0.28	0.28	0.27	0.27	0.24
630	0.55	0.39	0.34	0.33	0.34	0.35	0.36	0.36	0.35	0.34
800	0.82	0.55	0.45	0.40	0.41	0.42	0.44	0.45	0.45	0.45
1000	1.21	0.79	0.62	0.51	0.49	0.50	0.52	0.54	0.55	0.57
1250	1.80	1.15	0.87	0.66	0.61	0.61	0.62	0.64	0.66	0.69
1600	2.78	1.77	1.31	0.94	0.81	0.77	0.77	0.78	0.80	0.84
2000	4.05	2.65	1.94	1.32	1.09	1.00	0.96	0.96	0.97	1.01
2500	5.79	3.95	2.89	1.92	1.53	1.34	1.25	1.21	1.20	1.22
3150	8.09	5.91	4.40	2.89	2.23	1.90	1.71	1.61	1.56	1.52
4000	10.93	8.80	6.75	4.45	3.37	2.80	2.47	2.26	2.13	2.00
5000	13.82	12.40	9.93	6.69	5.05	4.13	3.57	3.21	2.97	2.70
6300	16.80	17.03	14.52	10.18	7.71	6.27	5.36	4.75	4.33	3.82
8000	19.65	22.54	20.79	15.54	11.96	9.73	8.27	7.28	6.57	5.65
10000	22.05	27.97	27.98	22.65	17.91	14.69	12.50	10.96	9.84	8.35

(f) Temperature = 25.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
63	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00
80	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
100	0.07	0.05	0.05	0.03	0.03	0.02	0.02	0.02	0.01	0.01
125	0.09	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
160	0.11	0.10	0.10	0.08	0.06	0.05	0.04	0.04	0.03	0.03
200	0.14	0.13	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.04
250	0.17	0.17	0.17	0.15	0.13	0.11	0.10	0.09	0.08	0.07
315	0.21	0.20	0.21	0.20	0.19	0.17	0.15	0.13	0.12	0.10
400	0.26	0.25	0.26	0.26	0.25	0.24	0.22	0.20	0.18	0.16
500	0.34	0.30	0.31	0.32	0.33	0.32	0.30	0.28	0.26	0.23
630	0.46	0.38	0.37	0.39	0.41	0.41	0.40	0.39	0.37	0.34
800	0.66	0.50	0.46	0.47	0.50	0.52	0.52	0.52	0.51	0.48
1000	0.96	0.68	0.59	0.57	0.59	0.62	0.64	0.65	0.66	0.64
1250	1.40	0.95	0.78	0.69	0.70	0.74	0.77	0.79	0.81	0.82
1600	2.17	1.42	1.11	0.91	0.88	0.89	0.93	0.96	0.99	1.04
2000	3.24	2.09	1.59	1.21	1.10	1.09	1.11	1.14	1.18	1.25
2500	4.79	3.11	2.32	1.67	1.45	1.37	1.36	1.38	1.41	1.49
3150	7.09	4.71	3.49	2.42	2.00	1.82	1.74	1.72	1.73	1.79
4000	10.35	7.23	5.38	3.64	2.90	2.54	2.35	2.26	2.22	2.23
5000	14.24	10.65	8.07	5.42	4.22	3.60	3.25	3.04	2.92	2.83
6300	19.00	15.60	12.19	8.25	6.35	5.31	4.69	4.30	4.04	3.77
8000	24.33	22.40	18.38	12.79	9.82	8.12	7.06	6.36	5.88	5.31
10000	29.31	30.25	26.37	19.14	14.81	12.20	10.53	9.39	8.59	7.56

Table continued

(g) Temperature = 30.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
63	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
80	0.05	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
100	0.07	0.05	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
125	0.09	0.07	0.06	0.04	0.03	0.03	0.02	0.02	0.02	0.01
160	0.12	0.11	0.09	0.07	0.05	0.04	0.04	0.03	0.03	0.02
200	0.16	0.15	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04
250	0.19	0.19	0.18	0.15	0.12	0.10	0.09	0.08	0.07	0.06
315	0.23	0.24	0.24	0.21	0.18	0.16	0.14	0.12	0.11	0.09
400	0.29	0.29	0.30	0.29	0.26	0.23	0.21	0.19	0.17	0.14
500	0.35	0.35	0.37	0.38	0.36	0.33	0.30	0.27	0.25	0.21
630	0.45	0.42	0.44	0.47	0.47	0.45	0.42	0.39	0.37	0.32
800	0.60	0.53	0.53	0.57	0.60	0.60	0.58	0.56	0.53	0.47
1000	0.82	0.66	0.64	0.68	0.72	0.75	0.75	0.74	0.72	0.67
1250	1.15	0.87	0.80	0.81	0.86	0.90	0.93	0.94	0.94	0.90
1600	1.74	1.23	1.06	0.99	1.03	1.09	1.14	1.18	1.20	1.21
2000	2.56	1.74	1.42	1.24	1.24	1.29	1.36	1.41	1.46	1.52
2500	3.82	2.53	1.99	1.61	1.53	1.55	1.61	1.67	1.74	1.84
3150	5.77	3.79	2.90	2.20	1.99	1.94	1.96	2.01	2.08	2.21
4000	8.77	5.82	4.39	3.17	2.72	2.54	2.49	2.50	2.54	2.67
5000	12.75	8.71	6.55	4.59	3.78	3.41	3.23	3.17	3.16	3.24
6300	18.28	13.15	9.98	6.87	5.51	4.81	4.43	4.23	4.12	4.08
8000	25.53	19.83	15.38	10.59	8.33	7.11	6.39	5.95	5.68	5.42
10000	33.41	28.45	22.83	15.94	12.45	10.48	9.27	8.49	7.96	7.35

(h) Temperature = 35.0°C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
63	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
80	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00
100	0.06	0.05	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.01
125	0.09	0.07	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.01
160	0.13	0.11	0.09	0.06	0.05	0.04	0.03	0.03	0.02	0.02
200	0.17	0.15	0.13	0.09	0.07	0.06	0.05	0.04	0.04	0.03
250	0.22	0.20	0.18	0.14	0.11	0.09	0.08	0.07	0.06	0.05
315	0.27	0.27	0.25	0.21	0.17	0.14	0.12	0.11	0.09	0.08
400	0.33	0.35	0.34	0.30	0.25	0.22	0.19	0.17	0.15	0.12
500	0.40	0.42	0.43	0.41	0.36	0.32	0.28	0.25	0.22	0.18
630	0.48	0.50	0.53	0.54	0.50	0.46	0.41	0.37	0.34	0.29
800	0.60	0.61	0.64	0.68	0.68	0.64	0.60	0.56	0.51	0.44
1000	0.77	0.73	0.76	0.83	0.86	0.85	0.82	0.78	0.73	0.64
1250	1.03	0.90	0.90	0.98	1.05	1.08	1.07	1.05	1.01	0.92
1600	1.48	1.18	1.12	1.18	1.27	1.34	1.38	1.38	1.37	1.31
2000	2.12	1.58	1.42	1.41	1.50	1.59	1.67	1.72	1.74	1.73
2500	3.10	2.19	1.87	1.73	1.78	1.88	1.98	2.06	2.13	2.19
3150	4.66	3.18	2.59	2.22	2.18	2.25	2.36	2.46	2.56	2.71
4000	7.16	4.80	3.78	3.00	2.80	2.79	2.86	2.96	3.08	3.28
5000	10.65	7.14	5.51	4.15	3.69	3.54	3.53	3.59	3.69	3.91
6300	15.91	10.85	8.29	6.01	5.11	4.72	4.56	4.53	4.57	4.75
8000	23.56	16.70	12.79	9.06	7.44	6.64	6.23	6.03	5.95	5.99
10000	33.02	24.75	19.20	13.50	10.87	9.47	8.67	8.20	7.92	7.72

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Table concluded

(i) Temperature = 40.0 °C

Frequency, Hz	Relative Humidity (%)									
	10	15	20	30	40	50	60	70	80	100
50	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
63	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
80	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00
100	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
125	0.09	0.06	0.05	0.03	0.03	0.02	0.02	0.01	0.01	0.01
160	0.13	0.10	0.08	0.05	0.04	0.03	0.03	0.02	0.02	0.02
200	0.18	0.14	0.12	0.08	0.06	0.05	0.04	0.04	0.03	0.03
250	0.24	0.20	0.17	0.13	0.10	0.08	0.07	0.06	0.05	0.04
315	0.31	0.29	0.25	0.19	0.15	0.12	0.11	0.09	0.08	0.07
400	0.39	0.39	0.36	0.29	0.23	0.19	0.17	0.15	0.13	0.10
500	0.47	0.49	0.48	0.41	0.35	0.29	0.25	0.22	0.20	0.16
630	0.56	0.60	0.62	0.57	0.50	0.44	0.38	0.34	0.31	0.25
800	0.68	0.73	0.77	0.77	0.72	0.65	0.58	0.52	0.47	0.40
1000	0.82	0.86	0.92	0.98	0.96	0.90	0.83	0.76	0.70	0.59
1250	1.03	1.02	1.08	1.19	1.22	1.20	1.14	1.08	1.01	0.88
1600	1.38	1.26	1.30	1.44	1.54	1.57	1.56	1.51	1.45	1.31
2000	1.88	1.59	1.56	1.69	1.84	1.93	1.97	1.97	1.94	1.83
2500	2.65	2.08	1.94	2.01	2.17	2.31	2.41	2.47	2.49	2.44
3150	3.89	2.87	2.54	2.44	2.57	2.74	2.90	3.02	3.10	3.17
4000	5.90	4.16	3.50	3.12	3.15	3.29	3.47	3.63	3.78	3.98
5000	8.79	6.05	4.90	4.08	3.92	3.99	4.14	4.31	4.49	4.80
6300	13.31	9.09	7.17	5.62	5.14	5.03	5.09	5.23	5.40	5.77
8000	20.31	13.98	10.88	8.15	7.11	6.69	6.57	6.59	6.70	7.03
10000	29.69	20.96	16.26	11.86	9.99	9.11	8.69	8.51	8.49	8.68

## **Appendix E**

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## **Secondary Treatment Facilities Plan**

### **Volume III**

#### **Appendix E Air Emissions**

## 1.0 SUMMARY

This appendix investigates the emissions of odor-causing compounds and volatile organic compounds (VOCs) from the Deer Island treatment plant and the Nut Island headworks, and the impacts of these emissions on ambient air quality. The other headworks, which are currently undergoing renovation, are not included in this assessment. Their impacts should be reviewed after their renovation is complete, and sampling is conducted.

The Commonwealth of Massachusetts has laws and regulations dealing with odors and VOCs. The laws for odors are set in general terms and seek to avoid nuisances. The laws and regulations for VOCs have specific numeric limits, however. These limits are set in regulations on two levels: 1) increase in emissions of VOCs, and 2) the ambient impact of individual potentially toxic compounds. The first concern sets limits on the total mass of VOCs emitted, and the second concern sets Allowable Ambient Levels (AALs) that should not be exceeded.

The sources of emissions from wastewater treatment are interfaces between wastewater and air, and emissions increase where the surfaces are turbulent. At the facilities proposed for Deer Island, the sources would be tank surfaces (such as clarifiers), weirs, and aeration tanks. For tank surfaces, wind increases emissions of volatiles. For aeration tanks, biodegradation removes some of the volatile organics.

Emissions from several sources were calculated, and their effects on ambient air quality were assessed. The sources included in these calculations were:

- o Weirs after the grit removal facilities
- o Primary splitter box
- o Weirs after primary clarifiers
- o Secondary splitter box
- o Aeration basins and their weirs
- o Secondary clarifier surfaces and weirs
- o Surface of disinfection basins.

Emissions from the grit-removal facilities and from the surface of the primary clarifiers were not estimated, because their amounts would be insignificant in comparison to the other emissions. These two surfaces will be quiescent and will be protected from the wind by covers. However, their emissions will be collected and treated, as will emissions from other minor sources such as vent shafts, Winthrop Terminal, the grit classifier building, aerated channels, and the screenings building.

All facilities up to the secondary clarifiers will be enclosed or covered. Their exhaust air will be collected and treated by wet scrubbing followed by activated carbon, at seven locations on the site. This treatment will decrease emissions of reduced sulfur by about 95 percent, and of VOCs by about 85 percent. The level of control proposed meets regulations for BACT (Best Available Control Technology).

Emissions of VOCs before and after control were estimated, and compared to existing emissions at Deer Island and Nut Island. After control, the emissions from Deer Island and Nut Island will be less than existing emissions. This means that the air pollution control facilities will not have to meet rules for LAER (Lowest Achievable Emission Rate). LAER would have had to be met if the total emissions exceeded existing emissions by more than 40 tons per year.

Air-quality modeling consisting of screening and detailed analyses were conducted. Projected impacts were compared to AALS. The comparison shows that the emissions after control will produce ambient impacts that are less than AALS.

Additional study is recommended to resolve some questions about emissions of VOCs. The sampling program measured VOCs from the EPA priority-pollutant and hazardous-substance lists, and other VOCs identified from searches of peaks on mass chromatographs. However, other VOCs, in addition to those measured, could be emitted. These other VOCs include volatiles already in the wastewater and volatiles produced during wastewater treatment. Data are lacking on these two types of emissions, and studies need to be under taken to assess their importance.

## 2.0 INTRODUCTION

Air pollutants in several forms can be released from wastewater treatment plants. Pollutants are released to the atmosphere during fuel storage and combustion in the form of gases and particulates; during the wastewater treatment processes in the form of gases and aerosols; and during the handling and ultimate disposal of the sludges produced in the form of gases and particulates.

Consideration of emissions from wastewater treatment plants is important because these emissions can cause odors and, if excessive, can be health hazards. In addition, the volatiles under consideration in this Appendix can react in the atmosphere to form ozone, an air pollutant that is irritating to the eyes and lungs, and which produces a summertime haze during stagnant conditions. The results of the investigations conducted dealing with the emissions of these pollutants and their control are presented in this Appendix.

The potential emissions of concern are those typically described as fugitive emissions, i.e., those typically escaping capture and control. The emissions being considered are the volatile constituents present in the wastewater that can be released as gases or aerosols at various points in the treatment process. They are generally classified as volatile organic compounds (VOCs) and odor-producing compounds. In the case of the Massachusetts Water Resources Authority (MWRA) assessment, however, these typically fugitive emissions are proposed for capture and control so as to minimize the environmental impact of the MWRA's operations.

This Appendix presents the methodology applied to assess the impacts of emissions of odor-causing compounds and VOCs from the Deer Island treatment plant and the Nut Island headworks, and presents the obtained results. This Appendix deals exclusively with the potential emissions resulting from treatment of wastewater at Deer Island and from the headworks facilities proposed for Nut Island. Emissions from other headworks that are now undergoing renovation are not included in this assessment. Their impacts should be reviewed after the renovations are complete, and sampling is conducted.

Issues related to power generation and sludge handling and disposal are also not considered. Emissions from power generation are covered in Appendix H. Emissions from sludge handling will be covered in the Solids Management Plan.

### 2.1 BACKGROUND

MWRA identified the potential release of VOCs and their subsequent impact on the environment as a key issue in the proposed improvements to the wastewater treatment facilities. To attempt to answer the questions dealing with environmental impacts and to resolve the uncertainties in emissions from wastewater treatment facilities, a detailed study was undertaken as part of the facilities plan. This study attempted to estimate the quantity of VOC emissions from the plant, determine the potential impact on the surrounding area, determine the regulatory requirements pertaining to the proposed construction, and devise a control scheme to maintain

the worst-case impact to below allowable levels. Throughout each step of the assessment, attempts were made to use the most accurate and current information on the behavior of these constituents in wastewater and the mechanisms leading to their release to the atmosphere. The results of these endeavors are presented in detail in this Appendix.

In brief, the methodology used to conduct the assessment was as follows:

Individual VOCs present in the wastewater entering the proposed treatment plant were identified and quantified.

The magnitude of VOC emissions from the plant were estimated using computerized mass-transfer programs. Estimates were provided for a worst-case day and for an average annual emission rate.

The cost of controlling these air emissions to a level as required by the Commonwealth of Massachusetts was evaluated.

The air quality impacts of the emissions escaping control at all locations of public access surrounding the proposed treatment plants were estimated.

## 2.2 ORGANIZATION

The remainder of this Appendix is divided into sections dealing with the various aspects of the assessment. Section 3 presents an overview of the regulatory requirements that were considered during the assessment. Section 4 presents the results obtained from a series of detailed sampling programs aimed at identifying pollutants present in the wastewater. Section 5 discusses the procedures used to quantify the fraction of the influent pollutants that are released to the atmosphere, and presents the results of the calculations for a number of possible worst-case operating scenarios. Section 6 discusses the alternatives available for controlling the air pollutants released from the wastewater treatment plant and provides a description of the proposed control system. Finally, Section 7 presents the methodology used to estimate the ambient air quality impacts of the pollutant releases and compares the calculated impacts with levels that are allowable.

### 3.0 REGULATORY REQUIREMENTS

#### 3.1 REVIEW AND APPROVAL PROCESS

Both the U.S. Environmental Protection Agency (EPA) and the Commonwealth of Massachusetts have adopted regulations for review and approval of new or modified sources of air pollutants before construction. The regulations specify procedures for obtaining preconstruction approval of a new or modified source and present topics that must be considered during the planning phase. Specific source performance or impact requirements exist for "criteria" air pollutants (particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, and photochemical oxidants or ozone), hazardous air pollutants (arsenic, mercury, beryllium, benzene, vinyl chloride, radionuclides, and asbestos), and some specific sources as defined by the New Source Performance Standards (NSPS). The requirements for ozone are defined in terms of VOCs which, in Massachusetts, include all non-methane hydrocarbons (NMHC) with a vapor pressure greater than or equal to 0.1 millimeters of mercury (mm Hg).

Implementation of preconstruction source approval procedures is based on the extent of existing air contaminant levels in the area of the proposed construction and the magnitude of the air pollutant emission increases resulting from the proposed source. For the purpose of determining which procedures apply, the ambient criteria air pollutant concentrations existing in each area of the U.S. are compared with the levels prescribed by the National Ambient Air Quality Standards (NAAQS). Areas that display pollutant levels less than those prescribed by the NAAQS are classified as attainment areas and are subject to rules for Prevention of Significant Deterioration (PSD), whereas areas with pollutant levels greater than the NAAQS are classified as nonattainment areas and are subject to the rules of nonattainment review and to emission offsets. The appropriate set of rules is applied to all new major sources (those with the potential to emit 100 tons or more of a specific air pollutant) and all major modifications to existing major sources (those with the potential to increase the air pollutant emissions by a significant amount). With respect to a major modification, significant is defined on a pollutant-specific basis in 310 CMR 7.00 Appendix A for nonattainment areas and 40 CFR 51.21(b)(23)(i) for attainment areas. Both of these stations define a significant VOC increase as 40 tons per year.

In addition to the established requirements for preconstruction review, informal review requirements are often applied during the approval process. These requirements help to ensure that the releases of potentially toxic air pollutants not otherwise covered by regulation do not produce an ambient impact that would pose an undue risk to members of the public. Although toxic emission review is performed differently in each state, the general concept involves comparison of the ambient impact of acutely toxic compounds to safe levels based on sensitive populations, and comparison of the ambient impacts of chronically toxic compounds to a specific allowable risk level.

The concern regarding emissions from the proposed Deer Island facility is related to preconstruction review on two levels: 1) review of the VOC emission increase from the proposal, and 2) review of the ambient impact of individual potentially toxic compounds. The area in which the proposed construction will take place is classified as nonattainment for ozone; thus,



nonattainment review is required for the VOCs. The VOC review first entails determining the extent of emissions baseline. If the baseline emission rate is greater than or equal to 40 tons of VOCs per year, the existing source is classified as a major source. A proposed VOC emission increase of 40 tons or more per year at a major source requires that the proposed source reduce its air pollutant emissions through the application of technology capable of Lowest Achievable Emission Rates (LAER). The emission increase must be offset by reducing VOC emissions at another existing source. A less-than-significant VOC emission increase at a major source, or a non-major new source, must apply the Best Available Control Technology (BACT) to reduce its potential VOC emission.

Air toxic review entails determining that the emission rates of potentially toxic air pollutants from the entire proposed facility do not cause incremental ambient air pollutant concentrations in excess of Allowable Ambient Levels (AALs). The AALs represent the maximum allowable ambient air quality impacts of pollutants released from the proposed facility at any point accessible to the public. Unlike the NAAQS, air toxic review does not entail a definition of existing ambient concentration for pollutants undergoing review. Massachusetts reviews the impact of toxic air pollutants using the procedure described in a report entitled The Chemical Health Effects Assessment Methodology and the Method to Derive Allowable Ambient Levels (CHEM/AAL)1.

### 3.2 BASELINE CONDITIONS

A definition of baseline conditions must be established prior to determining the level of VOC control that must be applied to the proposed source. A baseline is determined for an entire facility (as opposed to a single unit within a facility), and is generally representative of its routine, actual operation during the two-year period immediately preceding the application date (310 CMR 7.00 Appendix A (2)). The Massachusetts Department of Environmental Quality Engineering (DEQE) considers each of the existing and proposed wastewater project elements as "sources" to be reviewed and regulated separately, with the baseline condition representing conditions in existence or permitted as of December 31, 1986. Two sources are considered in this Appendix -- the Deer Island plant and the Nut Island headworks. The other headworks are undergoing renovation, and their impacts should be reviewed after their renovation is complete, and sampling is conducted.

The significance of the baseline condition is that it is used to define whether or not an existing source is a major source of air pollutants. A source is defined as major or non-major on a pollutant-by-pollutant basis. In the case of the Deer Island project, the existing source is a major source when the baseline emission rate of VOCs is equal to or greater than 100 tons per year (tons/yr). No such designation exists for sources of potentially toxic air pollutants, as all new or modified sources must undergo the same level of preconstruction review.

### 3.3 APPLICABLE REQUIREMENTS

#### 3.3.1 REQUIREMENTS ON ODORS

In Massachusetts, odors are regulated by Boards of Health and the State Department of Health, by the Division of Air Pollution Control, and by the Division of Water Pollution Control. The Boards of Health and the Department of Health obtain their authority from Massachusetts General Law, Chapter 111, Section 122. The Division of Air Pollution Control is empowered by the Massachusetts Air Pollution Control Regulations (310 CMR 7). The Division of Water Pollution Control relies on Massachusetts General Law, Chapter 83, Sections 6 and 7.

None of these laws and regulations sets numerical limits for odor. Rather, these regulations state limits for odors only in general terms. These limits attempt to eliminate nuisances and to avoid injury to the public health. However, specific limits have been investigated and odor thresholds have been used in assessing the impact of odor-producing compounds.

#### 3.3.2 REQUIREMENTS FOR VOC CONTROL

DEQE regulations for control of new or modified sources do not present pollutant-specific or source-specific requirements for wastewater treatment facilities. General provisions can be found, however, in 301 CMR 7.02. This regulation requires that all new or modified sources of air pollutants include, at a minimum, application of the BACT to control VOC discharges. A modification to an existing major source must incorporate equipment capable of meeting LAER to control VOC discharges if it is determined that after the application of BACT, the proposed increase above the baseline emission rate is greater than or equal to 40 tons/yr. This emission increase must also be offset by obtaining an equal reduction (plus an additional ten percent reduction) in the level of VOC emissions from an existing source so as to demonstrate reasonable further progress toward attainment of the O<sub>3</sub> NAAQS. Details on the definitions of BACT and LAER are provided in Section 6 of this Appendix.

Based on the emission calculation procedures documented in Section 5, the proposed Deer Island facilities will emit 98.2 tons/yr of individual volatile constituents before control. Application of BACT to these emissions will reduce the amount released to 14.7 tons/yr. Based on the ratio discussed above, the total VOC emission rate, after application of BACT, will be between 293 and 734 tons/yr on Deer Island. Thus, at the completion of the secondary treatment system upgrade, the emission of both individual air pollutants and total VOCs will be reduced when compared to baseline conditions, despite the uncertainty in the actual VOC emission rate. Similar conclusions are derived based on Nut Island emission rates. As a result, the determination has been made that the proposed construction on Deer and Nut Islands is subject to BACT control of VOCs. LAER is not needed and emission offsets will not be required. Details on the conclusions provided are presented in Sections 5 and 6.

#### 3.3.3 REQUIREMENTS FOR CONTROL OF INDIVIDUAL POLLUTANTS

Satisfaction of an air pollutant control level is only part of the required preconstruction review process. The ambient impacts of individual constituents must also be less than levels

prescribed by the AALs. The AALs developed by DEQE represent the maximum allowable 24-hour ambient concentrations that can be produced by emission of certain pollutants from the proposed facilities. As is consistent with air toxic review in other areas of the country, compliance with the AALs in Massachusetts requires that the calculated incremental ambient impact be less than the AAL at all locations of public access beyond the fence line of the facility. For odor-causing compounds, odor thresholds were used in assessing the impact on ambient levels at the fence line.

Finally, PSD regulations (40 CFR 51.21) require BACT review in attainment areas for a variety of non-criteria air pollutants released in significant amounts. Although the project is not subject to PSD review for VOCs, other air pollutants will trigger the PSD review requirements for these non-criteria pollutants. With respect to the wastewater treatment facilities, the only other pollutants requiring specific PSD review are the compounds included in the category "total reduced sulfur" (TRS). These include hydrogen sulfide, mercaptans, and carbon disulfide. The significant emission rate for TRS is 10 tons per year.

### 3.3.4 DERIVATION OF ALLOWABLE AMBIENT LEVELS

The individual constituents considered in this assessment and the AAL for each constituent are listed in Table 3.3.4-1. The odor threshold levels for some of the pollutants are also provided. Five of the constituents listed in this table are carcinogens, potential carcinogens, or suspected carcinogens, and are commonly reviewed for their potential to induce cancer in exposed populations. The constituents commonly reviewed as carcinogens are also indicated in this table.

AALs for all noncarcinogenic constituents listed in Table 3.3.4-1 were obtained from DEQE's list of AALs (1) or were calculated and submitted to DEQE for review and concurrence. Constituents for which no AAL has been derived are also identified. The AALs for the carcinogenic constituents were calculated on an annual basis using data generated by EPA's Carcinogen Assessment Group (CAG) or Health Effects Assessment (HEA) group. The calculation involved transforming the published cancer potency factor, given in terms of the inverse of milligrams of intake per kilogram of body weight per day [(mg/kg-day)<sup>-1</sup>], into an allowable 24-h ambient concentration presented in terms of micrograms per cubic meter (5g/m<sup>3</sup>). The transformation from cancer potency (which assumes constant exposure over an average lifetime of 70 years) to an annual AAL required establishing an allowable risk level (1 in 100,000 per DEQE), a daily inhalation rate (20 m<sup>3</sup>/day per CAG), and an average human body weight (70 kg per HEA and CAG). The annual concentration was transformed to a 24-h concentration by multiplying by the 24-h conversion factor of 3.35. This factor is based on meteorological data for Logan Airport and accounts for the relationship between concentrations over the two different averaging times. The derivation of the conversion factor is discussed in Section 7.2.

The ambient impact of each individual constituent was calculated based on the emission estimation procedures presented in Section 5 and the dispersion modeling procedures presented in Section 7. The impact of each constituent was compared with the most stringent ambient concentration level shown in Table 3.3.4-1 (i.e. AAL or odor threshold) to determine whether the impacts of the treatment facilities were within allowable or acceptable limits.

**TABLE 3.3.4-1**  
**Allowable Ambient Levels for Individual Constituents in the Treatment Plant Influent**

CAS No	Constituent Name	Odor Threshold, µg/m <sup>3</sup>	Allowable Ambient Level, µg/m <sup>3</sup>
67-64-1	Acetone	240000	8000
71-43-2	Benzene (C) <sup>1</sup>	15000	4
100-51-6	Benzyl alcohol	24700	NA <sup>2</sup>
74-83-9	Bromomethane	NA	NA
78-93-3	Butanone (MEK)	29900	160
36687-98-6	2-Butanone, 3-methoxy, 3-methyl	NA	NA
75-15-0	Carbon disulfide	663	NA
108-90-7	Chlorobenzene	980	.63
67-66-3	Chloroform (C)	10 <sup>6</sup>	1.44
95-48-7	o-Cresol	1170	NA
106-44-5	p-Cresol	2.02	12
95-50-1	1,2-Dichlorobenzene	24400	82
624-92-0	Dimethyl disulfide	5.0	NA
75-18-3	Dimethyl sulfide	2.57	NA
100-41-4	Ethyl benzene	615000	20
60-29-7	Ethyl ether	2550	160
108-10-1	Hexone (MIBK)	1950	280
74-93-1	Methyl mercaptan	4.19	NA
75-09-2	Methylene chloride (C)	8000	8
91-20-3	Naphthalene	NA	14
86-30-6	N-Nitrosodiphenylamine	NA	NA <sup>2</sup>
62108-41-2	Pentane, 2-meth, 2,4,4-trimethyl	NA	NA
108-95-2	Phenol	195	52
403-51-3	2-Propanone, 1-flouro	NA	NA
100-42-5	Styrene	639	39
79-34-5	1,1,2,2-Tetrachloroethane	3480	1.2
127-18-4	Tetrachloroethene (C)	34400	21
108-88-3	Toluene	649	51
540-59-0	Trans-1,2-dichloroethylene	341	110
71-55-6	1,1,1-Trichloroethane	553000	1300
79-01-6	Trichloroethene (C)	272000	20.4
75-69-4	Trichlorofluoromethane	NA	762
	Xylene	220	59

1 Reviewed as a carcinogen.

2 No data available.

## REFERENCES FOR SECTION 3

The Chemical Health Effects Assessment Methodology and The Method to Derive Acceptable Ambient Levels, Prepared by The Commonwealth of Massachusetts, Department of Environmental Quality Engineering, June 1985. With updates issued May 14, 1987.

General References for Derivation of Odor Thresholds and Allowable Ambient Levels:

U.S. Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment, 51 FR 33992-34054, September 24, 1986.

U.S. Environmental Protection Agency, Superfund Public Health Evaluation Manual, EPA 540/1-86-060, OSWER Directive 9285.4-1, October 1986.

U.S. Environmental Protection Agency, Carcinogen Assessment Group, Relative Carcinogenic Potencies Among 54 Chemicals Evaluated by CAG As Suspect Human Carcinogens, 1985. Verified by verbal communication 7/9/87.

U.S. Environmental Protection Agency, Health Effects Assessment for (various chemicals, 58 individual documents), Verified by written communication 7/14/87.

U.S. Environmental Protection Agency, Chemical Emergency Preparedness Program, Volume 2, Chemical Profiles, November 1985.

U.S. Coast Guard, Department of Transportation, Chemical Hazards Response Information System (CHRIS), Manual II: Hazardous Chemical Data, 1984.

Handbook of Environmental Data On Organic Chemicals, published by Van Nostrand Reinhold Company, New York, NY, Karel Verschueren, editor, Copyright by Litton Educational Publishing Company, 1977.



## 4.0 POLLUTANTS TO CONSIDER AND THEIR QUANTITIES

### 4.1 DEFINITION OF VOLATILE ORGANICS

Compounds are defined as volatile or non-volatile according to their vapor pressure. The Massachusetts Air Pollution Control Regulations (310 CMR 7) define a volatile organic compound (VOC) as "any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides, or carbonates, ammonium carbonate, methane, and ethane) that has a vapor pressure greater than 0.10 mm of Hg (0.0019 psi) at a temperature of 20 degrees Centigrade (68 degrees Fahrenheit)."

### 4.2 SOURCES OF DATA REGARDING QUANTITIES OF COMPOUNDS

The sampling studies conducted in Fall 1986 and Spring 1987 are described in Section 6.1 of Volume III of the Facilities Plan. The sampling program specified analyses for more than 150 compounds from EPA's Priority Pollutant List and Hazardous Substances List, and supplemented those compounds by searches of mass spectrographs to identify and quantify other organic compounds.

For analysis of air emissions, only the detected pollutants having a vapor pressure higher than 0.1 mm Hg, as defined in Massachusetts regulations were included. Most of these pollutants were part of the "volatile" fractions of the Priority Pollutant List, but some were also measured under the acid and base/neutral analyses.

The procedure for statistically analyzing the results and for projecting loads and flows to the design year are described in Section 6.2 of Volume III.

### 4.3 ESTIMATES OF FLOWS AND LOADING

The procedures for estimating the flows and mass loadings are described in Section 10.6.5 of Volume III of the Facilities Plan. These tables are included in this section and provide the concentrations of volatile organics as follows:

Table 4.3-1	Projected concentrations of volatile organics at Deer Island
Table 4.3-2	Projected concentrations of volatile organics at Nut Island
Table 4.3-3	Comparison of Annual Controlled Constituent Emission Estimates for Existing and Proposed Treatment Systems on Deer and Nut Islands.
Table 4.3-4	Short-Term Controlled Constituent Emission Estimates Under Various Flow and Load Conditions for the Existing and Proposed Treatment Systems on Deer and Nut Islands.
Table 4.3-5	Actual Short-Term Constituent Emission Estimates Under Various Flow and Load Conditions for the Existing and Proposed Treatment Systems on Deer and Nut Islands.



**TABLE 4.3-1**  
**Projected Concentrations of VOCs in Influent to Deer Island**  
**(Includes Deer And Nut Island)**

Constituent	Influent Concentration with average load and average flow = 480 MGD (µg/L)	Influent Concentration with average load and average low ground- water flow = 390 MGD (µg/L)	Influent Concentration with average load and average high ground- water flow = 670 MGD (µg/L)	Influent Concentration with maximum load and minimum flow = 320 MGD (µg/L)	Influent Concentration with maximum load and maximum flow = 960 MGD (µg/L)	Influent Concentration with maximum load with storm load, maximum plus storm flow = 1270 MGD (µg/L)
<b><u>VOLATILES</u></b>						
Bromomethane	15.57	19.17	11.16	42.74	14.25	10.77
Methylene Chloride	30.06	36.99	21.53	120.50	40.17	30.36
Acetone	96.75	119.08	69.31	414.17	138.06	151.79
Carbon Disulfide	7.90	9.72	5.66	19.44	6.48	8.77
trans-1,2-Dichloroethene	7.35	9.04	5.26	18.80	6.27	5.47
Chloroform	5.06	6.23	3.63	15.76	5.25	6.90
2-Butanone	23.69	29.16	16.97	79.37	26.46	31.61
1,1,1-Trichloroethane	11.99	14.76	8.59	35.88	11.96	11.48
Trichloroethene	10.39	12.79	7.44	34.87	11.62	11.71
Benzene	3.58	4.41	2.57	7.67	2.56	5.11
4-Methyl-2-Pentanone	18.56	22.85	13.30	51.62	17.21	22.11
Tetrachloroethene	13.62	16.76	9.76	48.26	16.09	22.66
1,1,2,2-Tetrachloroethane	8.44	10.38	6.04	19.11	6.37	5.55
Toulene	17.45	21.47	12.50	64.37	21.46	18.42
Chlorobenzene	8.03	9.88	5.75	19.68	6.56	7.40
Ethylbenzene	8.27	10.18	5.93	25.45	8.48	6.90
Styrene	8.65	10.65	6.20	20.28	6.76	9.35
Total Xylene; M, O, and P	24.66	30.35	17.67	96.52	32.17	36.41
<b><u>ACID AND BASE NEUTRALS</u></b>						
Phenol	15.50	19.08	11.10	50.41	16.80	15.88
Benzyl Alcohol	19.90	24.49	14.26	54.58	18.19	23.51
1,2-Dichlorobenzene	18.69	23.01	13.39	51.38	17.13	12.95
2-Methylphenol	20.37	25.07	14.59	48.92	16.31	22.31
4-Methylphenol	17.58	21.63	12.59	49.61	16.54	21.12
Naphthalene	13.01	16.02	9.32	47.94	15.98	12.64
N-Nitrosodiphenylamine	19.89	24.48	14.25	49.57	16.52	22.24
<b><u>Non-Priority Pollutants</u></b>						
2 Propanol	6.39	7.86	4.58	13.42	4.47	6.51

2Butanone,3Methoxy,3Methyl	6.04	7.43	4.33	12.44	4.15	6.09
Bicyclo(3.1.1)Heptane,6,6-Di	7.47	9.20	5.35	27.54	9.18	10.60
Dimethly Disulfide	6.47	7.96	4.64	14.73	4.91	6.88
Ethane, 1,1 - Oxybis-	5.99	7.38	4.29	12.63	4.21	6.12
Ethanol	6.41	7.89	4.59	14.83	4.94	6.88
Ethanol, 2 Methoxy	6.18	7.61	4.43	12.64	4.21	6.21
1 - Hexanol	6.33	7.79	4.54	13.21	4.40	6.43
Methane Thiobus	10.28	12.66	7.37	50.26	16.75	17.71
Methane Thiol	19.19	23.62	13.75	52.11	17.37	22.54
Pentane, 2 Meth,2,4,4-Trimet	6.08	7.49	4.36	12.09	4.03	6.03
Trichlorofluoromethane	9.79	12.05	7.01	19.95	6.65	9.83

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**TABLE 4.3-2**  
**Projected Concentrations of VOCs in influent to Nut Island**

Constituent	Influent Concentration with average load and average flow = 150 MGD (µg/L)	Influent Concentration with average load and average low ground- water flow = 110 MGD (µg/L)	Influent Concentration with average load and average high ground- water flow = 230 MGD (µg/L)	Influent Concentration with maximum load and minimum flow = 100 MGD (µg/L)	Influent Concentration with maximum load and maximum flow = 360 MGD (µg/L)	Influent Concentration with maximum load with storm load, maximum plus storm flow = 360 MGD (µg/L)
<b><u>VOLATILES</u></b>						
Bromomethane	14.80	20.19	9.65	42.19	11.72	11.72
Methylene Chloride	26.27	35.83	17.13	178.87	49.69	49.69
Acetone	96.65	131.79	63.03	494.38	137.33	137.33
Carbon Disulfide	7.86	10.72	5.13	17.36	4.82	4.82
trans-1,2-Dichloroethene	6.39	8.71	4.17	19.71	5.48	5.48
Chloroform	3.79	5.17	2.47	10.44	2.90	2.90
2-Butanone	34.16	46.58	22.28	184.37	51.21	51.21
1,1,1-Trichloroethane	8.46	11.53	5.52	27.07	7.52	7.52
Trichloroethene	8.67	11.83	5.66	36.68	10.19	10.19
Benzene	2.80	3.82	1.83	7.78	2.16	2.16
4-Methyl-2-Pentanone	18.98	25.88	12.38	81.49	22.63	22.63
Tetrachloroethene	11.91	16.24	7.77	45.58	12.66	12.66
1,1,2,2-Tetrachloroethane	7.81	10.65	5.09	17.02	4.73	4.73
Toulene	10.25	13.97	6.68	30.34	8.43	8.43
Chlorobenzene	7.81	10.65	5.09	17.02	4.73	4.73
Ethylbenzene	6.25	8.52	4.07	20.86	5.79	5.79
Styrene	7.81	10.65	5.09	17.02	4.73	4.73
Total Xylene; M, O, and P	15.88	21.65	10.35	61.86	17.18	17.18
<b><u>ACID AND BASE NEUTRALS</u></b>						
Phenol	19.64	26.78	12.81	81.01	22.50	22.50
Benzyl Alcohol	23.02	31.39	15.01	75.60	21.00	21.00
1,2-Dichlorobenzene	23.41	31.92	15.27	74.66	20.74	20.74
2-Methylphenol	23.41	31.92	15.27	74.66	20.74	20.74
4-Methylphenol	14.24	19.42	9.29	61.95	17.21	17.21
Naphthalene	21.77	29.69	14.20	78.98	21.94	21.94
N-Nitrosodiphenylamine	21.85	29.79	14.25	78.63	21.84	21.84
<b><u>Non-Priority Pollutants</u></b>						
2 Propanol	6.44	8.78	4.20	14.05	3.90	3.90
2Butanone,3Methoxy,3Methyl	6.26	8.53	4.08	12.53	3.48	3.48
Bicyclo(3.1.1)Heptane,6,6-Di	6.26	8.53	4.08	12.53	3.48	3.48

Dimethyl Disulfide	7.33	9.99	4.78	22.84	6.35	6.35
Ethane, 1,1 - Oxybis-	6.26	8.53	4.08	12.53	3.48	3.48
Ethanol	6.26	8.53	4.08	12.53	3.48	3.48
Ethanol, 2 Methoxy	6.26	8.53	4.08	12.53	3.48	3.48
1 - Hexanol	6.26	8.53	4.08	12.53	3.48	3.48
Methane Thiobus	6.26	8.53	4.08	25.34	7.04	7.04
Methane Thiol	18.87	25.73	12.31	34.93	9.70	9.70
Pentane, 2 Meth,2,4,4-Trimet	6.26	8.53	4.08	12.53	3.48	3.48
Trichlorofluoromethane	8.59	11.71	5.60	15.90	4.42	4.42

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Notes:

Minimum flow equals:	100 MGD	Average low groundwater flow equals:	100 MGD
Average flow equals:	150 MGD	Average high groundwater flow equals:	230 MGD
Maximum flow equals:	360 MGD		
Storm flow equals:	0 MGD		

Maximum equals 2,3265 standard deviations above the mean average non-storm load.

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Conversion constant = 8.34

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**Table 4.3-3**  
**Comparison of Annual Controlled Constituent Emission Estimates For the Existing and Proposed Treatment Systems on Deer and Nut Islands. (tons/yr)**

Constituent	Deer Island			Nut Island	
	Existing	Proposed oxygen	air	Existing	Proposed
Benzene	0.64	0.20	0.20	0.09	0.01
Chloroform	0.91	0.39	0.41	0.13	0.02
Ethylbenzene	1.38	0.53	0.50	0.25	0.03
Methylene chloride	5.16	1.58	1.64	0.80	0.13
Tetrachloroethene	2.26	0.70	0.73	0.37	0.06
Toluene	3.10	0.92	0.90	0.30	0.05
Trans-dichloroethene (1,2)	1.37	0.41	0.44	0.23	0.03
1,1,1-Trichloroethane	2.15	0.92	1.11	0.27	0.04
Trichloroethene	1.68	0.80	0.77	0.26	0.04
Trichlorofluoromethane	1.97	0.55	0.61	0.30	0.05
Styrene	1.47	0.64	0.71	0.23	0.04
Acetone	0.43	0.13	0.09	0.10	0.01
2-Butanone	0.00	0.02	0.02	0.08	0.00
Total xylenes	4.65	1.29	1.30	0.46	0.08
1,1,2,2-Tetrachloroethane	0.14	0.13	0.18	0.08	0.00
Methyl mercaptan	2.84	0.59	0.63	0.60	0.09
Bromomethane	2.80	1.30	1.50	0.48	0.08
2-Propanone, 1-fluoro	0.02	0.07	0.03	0.03	0.00
Carbon disulfide	1.25	0.24	0.25	0.22	0.04
-Butanone, 3-methoxy, 3-methyl	0.02	0.06	0.04	0.01	0.00
Ethyl ether	0.09	0.10	0.12	0.02	0.00
Phenol	0.00	0.02	0.00	0.04	0.00
Naphthalene	1.29	0.64	0.64	0.58	0.10
Chlorobenzene	1.32	0.45	0.45	0.22	0.04
o-Cresol	0.00	0.00	0.00	0.00	0.00
p-Cresol	0.00	0.00	0.00	0.05	0.00
1,2-Dichlorobenzene	2.36	1.31	1.41	0.60	0.10
Benzenamine	0.00	0.07	0.00	0.00	0.00
Hexone (MIBK)	0.08	0.11	0.14	0.02	0.00
Benzyl alcohol	0.08	0.04	0.02	0.04	0.00
Pentane, 3-meth,					
2,2,4-trimethyl	0.81	0.43	0.46	0.16	0.03
Dimethyl disulfide	0.00	0.02	0.00	0.00	0.00
Dimethyl sulfide)	0.00	0.00	0.00	0.00	0.00
TOTAL	40.40	14.66	15.31	7.01	1.06

**Table 4.3-4**  
**Short-term Controlled Constituent Emission Estimates Under Various Flow and Load**  
**Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -**  
**Air System. (lb/day)**

Constituent	Nut Island		Deer Island			
	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.70	1.27	1.98
Chloroform	0.71	0.31	4.98	5.09	3.98	4.92
Ethylbenzene	1.35	0.55	7.58	6.55	5.97	5.34
Methylene chloride	4.36	5.23	28.27	27.35	21.57	14.65
Tetrachloroethene	2.02	1.29	12.40	10.76	8.39	10.67
Toluene	1.64	8.08	17.01	13.97	10.97	8.56
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.66	3.81	3.19
1,1,1-Trichloroethane	1.46	0.76	11.78	12.12	12.05	13.48
Trichloroethene	1.45	0.98	9.21	10.28	10.23	12.28
Trichlorofluoromethane	1.65	0.51	10.82	5.22	4.49	6.86
Styrene	1.25	0.50	8.03	6.54	5.13	6.67
Acetone	0.53	0.21	2.37	1.72	1.10	0.86
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.86	15.33	14.09
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	2.06	0.86	0.71
Methyl mercaptan	3.29	1.02	15.58	3.73	3.15	3.86
Bromomethane	2.61	1.36	15.35	14.57	15.22	14.11
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.14	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.18	2.23	3.53
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.43	0.15	0.22
Ethyl ether	0.11	0.03	0.47	1.36	0.57	0.78
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.73	7.10	4.43
Chlorobenzene	1.23	0.50	7.23	4.26	3.12	2.86
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.44	11.26	7.36
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.78	0.61	0.80
Benzyl alcohol	0.19	0.03	0.43	0.23	0.15	0.13
Pentane, 3-meth,						
2,2,4-trimethyl	0.88	0.33	4.46	3.63	2.65	3.42
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.03	0.01	0.01
<b>TOTAL</b>	<b>38.43</b>	<b>29.12</b>	<b>221.37</b>	<b>186.77</b>	<b>151.71</b>	<b>146.07</b>



**Table 4.3-5**  
**Actual Short-term Constituent Emission Estimates Under Various Flow and Load**  
**Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -**  
**Oxygen System. (lb/day)**

Constituent	Nut Island		Deer Island			
	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.69	1.26	1.95
Chloroform	0.71	0.31	4.98	4.80	3.51	3.87
Ethylbenzene	1.35	0.55	7.58	6.77	6.32	5.79
Methylene chloride	4.36	5.23	28.27	26.01	19.57	12.21
Tetrachloroethene	2.02	1.29	12.40	10.15	7.37	8.30
Toluene	1.64	8.08	17.01	14.22	11.38	9.13
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.31	3.19	2.27
1,1,1-Trichloroethane	1.46	0.76	11.78	10.92	8.05	6.58
Trichloroethene	1.45	0.98	9.21	10.53	10.62	12.90
Trichlorofluoromethane	1.65	0.51	10.82	4.60	3.41	4.15
Styrene	1.25	0.50	8.03	6.16	4.52	5.24
Acetone	0.53	0.21	2.37	1.71	1.09	0.85
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.72	15.09	13.63
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	1.64	0.67	0.53
Methyl mercaptan	3.29	1.02	15.58	6.50	4.92	5.47
Bromomethane	2.61	1.36	15.35	13.78	10.73	7.31
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.13	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.38	1.83	2.14
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.40	0.14	0.20
Ethyl ether	0.11	0.03	0.47	1.08	0.44	0.58
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.69	0.70	4.36
Chlorobenzene	1.23	0.50	7.23	4.23	3.07	2.77
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.00	10.75	6.73
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.67	0.57	0.74
Benzyl alcohol	0.19	0.03	0.43	0.23	0.14	0.13
Pentane, 3-meth,						
2,2,4-trimethyl	0.88	0.33	4.46	3.53	2.53	3.12
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.01	0.01	0.01
TOTAL	38.43	29.12	221.37	183.22	132.21	121.24

#### 4.4 POLLUTANTS FOR WHICH MORE INFORMATION IS NEEDED

The VOCs identified in the sampling program are not the only organics that can be emitted from wastewater during wastewater treatment. These other VOCs include VOCs already in the wastewater and VOCs produced during wastewater treatment.

Besides the potentially toxic chemicals that were measured in the analyses conducted as part of the sampling program, the wastewater contains volatiles that are either not potentially toxic or are present individually in concentrations below detection limits. There are no good estimates of the concentrations of these compounds, but estimates of volatile organics in air spaces show that the concentrations can be considerable. At three plants in Cincinnati, gas chromatographic analysis for 24 specific compounds in air samples from the wet well and bar screen areas accounted for less than 10% of total VOCs<sup>(1)</sup>.

To investigate the total VOCs, data on emissions was examined from the Chelsea Creek, Columbus Park, and Ward Street Headworks. The data showed results of analyses of individual potentially toxic compounds and also of flame-ionization detection (FID) measurements. The FID measurements are estimates of the total volatile organic compounds. Ideally, the sum of the individual compounds should approximately equal the FID measurement. (The two would not match, however, because the FID test measures the carbon content of a sample, rather than the total mass).

The ratios of the FID measurements were calculated, and divided by the sum of the individual species. The results are shown on Table 4.4-1. No consistent statistical relationship was found between the total VOCs and the sum of the individual constituents. The results show that the ratio of the total VOCs to the sum of the individual species ranges from about 20 to 50 to 1. That is, for every lb of VOC measured by testing for individual compounds in air samples at the headworks, there might actually be a total of 20 to 50 lb of total VOCs. This ratio is important in estimating the potential for emissions of VOCs, and more information needs to be obtained about its magnitude. In the work for this project, data has been multiplied on the sum of individual components by 20 to 50 to estimate total VOCs.

In addition, volatile compounds can also be produced in biological treatment. These compounds can include volatile intermediate products or by-products such as alcohols, aldehydes, and terpenes. From measurements on effluent and gas streams from trickling filters in Indianapolis, Wukasz et al.<sup>(2)</sup> suggested that the trickling filters produce methane and nonmethane volatile organics.

For estimates of emissions, estimates for VOCs produced during treatment were not included. Therefore the estimates of emissions from activated sludge treatment might be low. However, no other information reports on the volatile compounds produced and emitted during wastewater treatment. Measurements on the potential for formation and emission of VOCs during biological treatment need to be obtained.

**Table 4.4-1**  
**Ratios of VOCs to the Sum of Individual Species in Air Samples**

Headworks	Number of Samples	<u>Total volatile organics/sum of species</u>	
		Average	Standard Deviation
Chelsea Creek	19	21.28	7.17
Columbus Park	18	34.24	17.88
Ward Street	20	43.52	45.99

#### References For Section 4.4

- (1) Dunovant, V. S., Clark, C. S., Que Hee, S. S., Hertzberg, V. S., and Trapp, J.H., "Volatile Organics in the Wastewater and Airspaces of Three Wastewater Treatment Plants." J. Water Pollut. Control Fed., 58, 866 (1986 ).
- (2) Wukasz, R. F., Dieterlen, J. P., and Keramida, V., "Mass Flow Rate of Volatile Organic Compounds from Wastewater Treatment Operations." Presented at the 59th Annual Conference of the Water Pollution Control Federation, Los Angeles (1986)

## 5.0 EMISSION ESTIMATION PROCEDURES AND RESULTS

### 5.1 INTRODUCTION

Eight combinations of activated sludge processes and wastewater flow/pollutant load conditions were selected for preliminary emissions estimation using the procedures and data described in Sections 5.2 and 5.3. The eight combinations consisted of two process variations and four conditions of flow and load. Process conditions included a diffused air system in the activated sludge process and pure oxygen feed to the activated sludge process. The four conditions of flow and load represented: average wastewater flow with average dry-weather constituent mass loadings; minimum wastewater flow with maximum dry-weather constituent mass loadings; maximum dry-weather flow with maximum constituent mass loadings; and maximum wastewater flow plus stormwater flow with maximum constituent mass loadings plus the storm constituent loadings. The rationale for selection of each emission estimate scenario is provided in Section 5.4. In general, these conditions were anticipated to produce the greatest short-term emission rate for subsequent dispersion modeling.

Computer calculations were performed on each of the selected scenarios as well as on the existing treatment system. The procedures used during emissions calculations, the program developed to perform the calculations, and the data input to each scenario are described throughout this Section.

### 5.2 DESCRIPTION OF REMOVAL MECHANISMS

Several mechanisms contribute to a loss of volatile compounds from wastewater treatment systems. The two major removal mechanisms were considered in this assessment -- volatilization and biodegradation. Volatilization is the only removal mechanism that leads to an atmospheric emission, and occurs when a molecule of a substance dissolved in the wastewater escapes from the liquid phase to an adjacent gas phase. The adjacent gas phase can be an air bubble within the liquid or in the atmosphere above the liquid. As such, emissions due to volatilization can occur from quiescent liquids such as those found in holding tanks or clarifiers, and from turbulent liquids such as those found at bar racks, weir overflows, and in aeration tanks. Biodegradation occurs when microbes decompose organic compounds for use in their metabolic processes. The rate of this decomposition varies by compound, depending on the compound's structure and the needs of the microbe for the compound. At a wastewater treatment plant, biodegradation occurs in the aeration tanks. Here biodegradation competes with volatilization as a removal mechanism. Thus lower air emissions are produced from the secondary treatment processes when biodegradation occurs.

In addition to the two major removal mechanisms considered, other mechanisms can also exist and these would tend to lower the amount of volatile material released from the treatment plant. These mechanisms include chemical oxidation and sludge partitioning. Chemical oxidation involves the degradation of compounds by oxygen, chlorine, or organic acids. Sludge partitioning involves the movement of a given compound from the liquid phase to the solid phase. These mechanisms were not considered in this assessment for three reasons: 1) they are less important than the mechanisms considered, 2) omission of these mechanisms will maximize

the calculated emission rates for all compounds considered, and 3) the procedures and data required to accurately determine the extent of removal by these mechanisms are not available.

The study of the mechanisms leading to atmospheric release of organic constituents from wastewater treatment plants has been pursued by various researchers over the past several years. The need to simulate releases under a variety of conditions has necessitated the development of computerized mass-balance techniques capable of performing the necessary calculations for many different unit processes. One of these techniques also coupled the calculated emission rates for individual constituents with an air pollutant dispersion model. This computer program was developed by the U.S. Environmental Protection Agency (EPA), and combines emission estimation with dispersion modeling using the EPA-approved Industrial Source Complex (ISC) model <sup>(1)</sup>. Because the framework for the present assessment was already included in the previously-developed EPA model, the EPA emission/dispersion model formed the basis of all emission calculations and subsequent ambient impact assessments. The basis of the model and the necessary refinements incorporated for the Deer Island assessment are described below.

## 5.2.1 VOLATILIZATION FROM TANK SURFACES

Tank surfaces at the Deer Island Facility will consist of the grit chambers, primary and secondary clarifiers, and the disinfection basins. The grit chambers and the primary clarifier surface will be covered, and because volatilization from quiescent surfaces is controlled by wind velocity, only the secondary clarifiers and the disinfection basins were modeled as quiescent surfaces. The Nut Island Facilities that were modeled as quiescent surfaces include the existing clarifiers and proposed distribution channels. The basic relationship describing the mass transfer of a chemical species from an open liquid surface to the air is expressed as:

$$E = K_L AC \quad (\text{Eq. 1})$$

where  $E$  = air emission rate from the liquid surface, grams/second (g/s)  
 $K_L$  = overall mass-transfer coefficient, meters/second (m/s)  
 $A$  = liquid surface area,  $m^2$   
 $C$  = concentration of constituent in the liquid phase,  $g/m^3$

The overall mass-transfer coefficient ( $K_L$ ) can be estimated from a two-phase resistance model that is based on the liquid- and gas-phase mass-transfer coefficients and the Henry's Law constant in the form of a unit-less partition coefficient. These two resistances act in series to yield an overall resistance expressed in the following equation:

$$1/K_L = 1/K_w + 1/(K_g K_{eq}) \quad (\text{Eq. 2})$$

where  $K_w$  = liquid-phase mass-transfer coefficient, m/s  
 $K_g$  = gas-phase mass-transfer coefficient, m/s  
 $K_{eq}$  = partition coefficient

The partition coefficient is the ratio of the concentration of a constituent in the gas phase and in the liquid phase, estimated as follows:



$$K_{eq} = HLC/RT \quad (\text{Eq. 3})$$

where HLC = Henry's Law constant, atm m<sup>3</sup>/gmole  
 R = universal gas constant, 8.21x10<sup>-5</sup> atm m<sup>3</sup>/gmole K  
 T = temperature, K

The liquid-phase mass-transfer coefficient is derived using a model developed by Springer et al.<sup>(2)</sup>:

$$K_w = [2.605 \times 10^{-9} (F/D) + 1.277 \times 10^{-7}] U^2 [D_w/D_{ether}]^{2/3} \quad (\text{Eq. 4})$$

where U = windspeed at 10 m above liquid surface, m/s  
 (minimum value input = 3.25 m/s)  
 D<sub>w</sub> = diffusivity of constituent in water, cm<sup>2</sup>/s  
 D<sub>ether</sub> = diffusivity of ether in water, cm<sup>2</sup>/s  
 F/D = fetch-to-depth ratio (fetch is the linear distance across the impoundment)

The gas-phase mass-transfer coefficient is estimated using the correlation developed by MacKay and Matasugu<sup>(3)</sup>:

$$K_g = 4.82 \times 10^{-3} U^{0.78} Sc_g^{-0.67} d_e^{0.11} \quad (\text{Eq. 5})$$

where Sc<sub>g</sub> = Schmidt number on the gas side  
 $= \mu \rho_g D_a$   
 μ = viscosity of air, g/cm s  
 ρ<sub>g</sub> = density of air, g/cm<sup>3</sup>  
 D<sub>a</sub> = diffusivity of constituent in air, cm<sup>2</sup>/s  
 d<sub>e</sub> = effective diameter of impoundment = (4A/π)<sup>1/2</sup>, m  
 A = area of impoundment, m<sup>2</sup>

The individual mass-transfer coefficients, along with the calculated K<sub>eq</sub>, are then applied to Equation 2 to determine the overall mass-transfer coefficient.

The flow model used in EPA's program for flow through quiescent impoundments assumes that the contents of the system are thoroughly mixed and that the bulk-concentration driving force is equal to the effluent concentration. A material balance for this flow model yields:

$$C = QC_o / (K_L A + Q) \quad (\text{Eq. 6})$$

where C = bulk concentration in impoundment, g/m<sup>3</sup>  
 Q = volumetric flow rate, m<sup>3</sup>/s  
 C<sub>o</sub> = initial concentration of constituent, g/m<sup>3</sup>

The well-mixed assumption is made for the sake of simplicity, and assumes that the bulk convection and wind-induced eddies combine to mix the impoundment contents. An assumed plug flow would yield slightly higher estimates; however, only minor amounts of the organic

constituents will be present in the impoundments modeled with this assumption, therefore the difference should be small.

### 5.2.2 VOLATILIZATION AT WEIRS AND HYDRAULIC STRUCTURES

Volatilization is strongly influenced by turbulence and, as a result, weirs used for flow control throughout the treatment plant are potential emission sources for the volatile constituents considered in this assessment. There were no reports found pertaining to the magnitude of volatile emissions due to turbulence at weirs and hydraulic structures, but there is information available about oxygen transfer at these structures. (A great deal of the procedures for estimating volatile releases from treatment systems are founded on the principles and mechanics of oxygen mass transfer). For estimates of volatile releases from wastewater flowing over weirs, the mass-transfer coefficients for oxygen were calculated and corrected by the ratio of the volatility of the constituent in question to oxygen.

The change in concentration of oxygen relative to saturation concentration as a liquid flows over a weir can be shown to be <sup>(4)</sup>:

$$1/r = (C_s - C)/(C_s - C_o) = \exp(-K_L a_o t) \quad (\text{Eq. 7})$$

where  $r$  = deficit ratio

$K_L a_o$  = mass-transfer coefficient,  $1/s$

$C_s$  = saturation concentration

$C_o$  = upstream concentration

$C$  = downstream concentration

$t$  = time

For a volatile constituent with a low concentration in the atmosphere,  $C_s$  becomes equal to zero and the equation reduces to:

$$1/r = C/C_o = \exp(-K_L a_v t) \quad (\text{Eq. 8})$$

This equation can be rewritten as:

$$\ln r = K_L a_v t \quad (\text{Eq. 9})$$

This means that ratios of the logarithm of  $r$  for different gases over the same weir (same value of  $t$ ) are related by the ratios of their values of  $K_L a$ .

Nakasone <sup>(5)</sup> has presented equations relating the values of  $r$  for oxygen over weirs with varying hydraulic conditions. He reports four equations for varying conditions:

$$\ln r_o = 0.0785 (D + 1.5 H_c)^{-1.31} q^{0.428} H^{0.31} \quad (\text{Eq. 10})$$

$$\text{for } (D + 1.5 H_c) \leq 1.2 \text{ m and } q \leq 235 \text{ m}^3/\text{h m}$$

where  $D$  = drop height, m

$H_c$  = critical water depth on the weir, m

$q$  = discharge per width of weir,  $m^3/h\ m$

$H$  = tail water depth, m

$$\ln r_o = 0.0861 (D + 1.5 H_c)^{0.816} q^{0.428} H^{0.31} \quad (\text{Eq. 11})$$

for  $(D + 1.5 H_c) > 1.2$  m and  $q \leq 235$   $m^3/h\ m$

$$\ln r_o = 5.39 (D + 1.5 H_c)^{1.31} q^{-0.363} H^{0.31} \quad (\text{Eq. 12})$$

for  $(D + 1.5 H_c) \leq 1.2$  m and  $q > 235$   $m^3/h\ m$

$$\ln r_o = 5.92 (D + 1.5 H_c)^{0.816} q^{0.363} H^{0.31} \quad (\text{Eq. 13})$$

for  $(D + 1.5 H_c) > 1.2$  m and  $q > 235$   $m^3/h\ m$

For simplification purposes and as suggested by Nakasone, the term  $D + 1.5 H_c$  was assumed to be equal to the change in elevations of the liquid surfaces before and after the weir. In order to determine the fraction of an organic constituent emitted through weir turbulence, the deficit ratio for the constituent was calculated for substitution into the appropriate equation above in terms of the deficit ratio for oxygen, as follows:

$$\ln r_v = \ln r_o (KLa_v/KLa_o) \quad (\text{Eq. 14})$$

where the subscripts o and v denote oxygen and volatile constituent, respectively.

For highly volatile organics (Henry's Law constant  $> 10^{-3}$ ), the ratio of mass-transfer coefficients can be related to diffusivity, described by Roberts <sup>(6)</sup> as follows:

$$KLa_v/KLa_o = (D_v/D_o)^{0.62} \quad (\text{Eq. 15})$$

where  $D_v$  = diffusivity of constituent in water at infinite dilution,  $cm^2/s$

$D_o$  = diffusivity of oxygen in water at infinite dilution,  $cm^2/s$

$$= 1.88 \times 10^{-5}$$

For low volatiles (Henry's Law constant  $< 10^{-3}$ ), the ratio of Henry's Law constants can be used as follows:

$$KLa_v/KLa_o = (HLC_v/HLC_o)^{0.6} \quad (\text{Eq. 16})$$

where  $HLC_o = 0.072$  atm  $m^3/gmole$

From these relationships, the fraction of volatiles emitted during weir overflow is calculated as:

$$f = 1 - (1/r_v) \quad (\text{Eq. 17})$$

### 5.2.3 VOLATILIZATION FROM AERATED SYSTEMS

Volatile constituents entering an aeration tank are removed from the liquid stream primarily by volatilization and biodegradation. (As noted previously, the effect of other mechanisms on removal are negligible.) Volatilization occurs as the constituent is transferred from the liquid phase to the gas phase, represented by the air or oxygen bubble fed to the system. Biodegradation occurs as the activated sludge consumes organic matter for reduction of the BOD content of the wastewater. The rate of removal by both of these mechanisms in an aeration tank is highly dependant on the oxygen mass transfer rate to the liquid.

Matter-Muller et al <sup>(7)</sup> and Roberts et al <sup>(8)</sup> have investigated the removal of volatiles from liquids by bubble aeration. Their work has shown that the degree of saturation of an air bubble leaving the surface of an aeration basin, i.e., the percent of equilibrium between the air bubble and the liquid, is a function of the mass-transfer rate and the Henry's Law constant, expressed as follows:

$$S = 1 - \exp[-(K_L a)V_L / K_{eq} Q_G] \quad (\text{Eq. 18})$$

where  $S$  = fraction of saturation  
 $V_L$  = aeration tank volume,  $m^3$   
 $Q_G$  = aeration air or oxygen flow,  $m^3/s$

For the aeration system at Deer Island, it has been determined that  $K_L a/Q_G$  remains constant for each flow condition. This is due to the fact that at higher flow rates the amount of air or oxygen input to the system is increased to handle the higher loads, thus increasing the oxygen transfer rate. This ratio, however, is not constant between the air and oxygen feed systems. This fact, combined with the relationships provided earlier in Equations 15 and 16, is used to calculate the fraction of saturation for each constituent present in the liquid as follows:

$$S_v = 1 - \exp[-(1.5 \times 10^{-5}) (V_L / K_{eq}) (HLC_v / HLC_o)] \quad (\text{Eq. 19})$$

for the air feed system, and

$$S_v = 1 - \exp[-(9 \times 10^{-4}) (V_L / K_{eq}) (HLC_v / HLC_o)] \quad (\text{Eq. 20})$$

for the oxygen feed system. The removal rate resulting from volatilization for each constituent is then calculated based on its partition coefficient and the fraction of saturation as:

$$R_s = Q_G K_{eq} C_o S \quad (\text{Eq. 21})$$

where  $R_s$  = removal rate,  $g/s$

$C_o$  = influent concentration,  $g/m^3$

In the case of the secondary splitter box, the influent concentration is equal to the effluent concentration from the immediately upstream treatment unit located immediately upstream (primary clarifier effluent weir), reduced by 1/3 to account for dilution of the pollutants by the return activated sludge flow. The rate of removal due to biodegradation is calculated in a similar fashion:

$$R_b = K_b C_o V_L \quad (\text{Eq. 22})$$

where  $R_b$  = removal rate, g/s  
 $K_b$  = rate constant for biodegradation, 1/s

These processes can be combined to estimate the effluent concentration of a volatile from a completely mixed aeration tank as:

$$C = C_o Q_L / (Q_L + K_b V_L + Q_G K_{eq} S) \quad (\text{Eq. 23})$$

where  $Q_L$  = liquid flow rate into the aeration tank  
 = wastewater flow plus return activated sludge flow

Based on previously established relationships, the fraction of the volatile constituent emitted (f) is expressed as the volatilization rate divided by the total removal rate due to volatilization and biodegradation:

$$f = Q_G K_{eq} S / (Q_L + K_b V_L + Q_G K_{eq} S) \quad (\text{Eq. 24})$$

The aeration basins for the Deer Island activated sludge systems will be designed to approach plug-flow units rather than completely mixed units. Plug-flow units can be modeled as a series of smaller completely mixed units, each one feeding a downstream unit. Alternately, the fraction of a volatile constituent emitted from the plug-flow units can be simulated (using the same relationships described above for volatilization and biodegradation) as:

$$f = [1 - \exp(-\{K_b + F\} V_L / Q_G)] [F / (K_b + F)] \quad (\text{Eq. 25})$$

where  $F = SK_{eq} Q_G / V_L$

The emission rate for the constituent of concern is then calculated by applying this fraction to the constituent mass loading rate as follows:

$$E = Q_L C_o f \quad (\text{Eq. 26})$$

where  $E$  = emission rate, g/s

### 5.3 DATA NEEDED FOR ESTIMATING EMISSIONS

Several types of data are needed to perform the required calculations. The general classes of data can fall into either a constituent category or a source category. Within each of these categories, the data can either remain constant between scenarios (e.g., constituent vapor pressure or treatment system dimensions) or vary between scenarios (e.g., constituent concentration or wastewater flow rate). To estimate emissions, properties of the constituents of interest and information relevant to the system design and operating parameters were compiled from the best available information sources. Discussion of these data is presented below.

#### 5.3.1 DATA FOR CONSTITUENTS OF INTEREST

The concentrations for the constituents of interest were presented previously in Section 4 and will not be repeated here. To facilitate the multitude of emission calculations, each constituent was assigned to a surrogate class. Some of the data used for calculations were derived from surrogate properties, while other data were input directly by constituent. Direct input was used for concentrations, biodegradation rate, and removal rate in the air pollution control system; data pertaining to Henry's Law and diffusivity were derived from the surrogate properties. With the exception of influent concentrations, data for the constituents remained constant between scenarios. The data, however, were adjusted to account (as indicated in Section 5.2) for influencing parameters such as temperature and oxygen transfer rates.

Table 5.3.1-1 presents a list of each constituent considered in the assessment, grouped by the surrogate class to which it was assigned, and provides the data used in the emission calculation program. Those constituents with higher Henry's Law constants will be more likely to be removed through volatilization than the ones with lower constants. Thus, they are especially susceptible to large releases due to weir turbulence since there are no competing mechanisms involved. Biodegradation, a competing mechanism in the aeration tanks, will tend to lower the aeration tank emission rate when the constituent has a high biorate. Those constituents with both low biorates and low Henry's Law constants will tend to pass through the system and be present in the treatment plant effluent.

The data presented in Table 5.3.1-1 were compiled from a variety of sources. Information on the actual Henry's Law constants were obtained from the US EPA's documentation of their emission/dispersion model (1). These data were used to establish the surrogate groups and the Henry's Law constants for each surrogate. Actual diffusivities for each constituent were also obtained from the EPA documentation, and were used to define the diffusivity value for each surrogate group.

The biodegradation rates were based on reported rate constants from a variety of sources (1, 9, 10, 11, 12). There is generally poor agreement within the literature on biological conversion rates, and much of the data was published based on high concentrations of single constituent wastes. As a result, some judgment had to be applied to selection of the biodegradation rates presented in Table 5.3.1-1. Those constituents for which no data could be found or derived were assumed to have a biodegradation rate equal to zero.



**TABLE 5.3.1-1**  
**Properties of Constituents Considered**

Surrogate No.	Compound	Actual Properties			Surrogate Properties	
		HLC <sup>1</sup>	Diffusivity <sup>2</sup>	Bio-rate <sup>3</sup>	HLC <sup>1</sup>	Diffusivity <sup>2</sup>
1	Trichlorofluoromethane	5.83E-02	9.70E-06	17	7.64E-02	1.10E-05
	Trans-dichloroethene (1,2)	8.50E-02		33		
	Bromomethane	2.21E-01		0		
2	Tetrachloroethene	2.90E-02		33	2.97E-02	8.80E-06
	1,1,1-Trichloroethane	3.00E-02	8.80E-06	0		
	Carbon Disulfide	1.68E-02		0		
3	Phenol	4.54E-07	9.10E-06	75	4.54E-07	9.10E-06
	Dimethyl Sulfide			0		
	Dimethyl Disulfide		1.50E-06	0		
	Benzenamine			67		
	o-Cresol	2.60E-06	8.30E-06	70		
	p-Cresol	4.43E-07		70		
4	2-Butanone, 3-methoxy 3-methyl			0	4.22E-05	1.06E-05
	Acetone	4.08E-05	1.14E-05	67		
	2-Butanone (MEK)	4.35E-05	9.80E-06	67		
	2-Propanone, 1-fluoro			0		
	Hexone (MIBK)	4.95E-05	7.80E-06	0		
	Benzyl Alcohol	1.39E-05		70		
5	1,2-Dichlorobenzene	1.94E-03	7.90E-06	0	1.59E-03	8.04E-06
	Pentane, 2-meth, 2,4,4 trimethyl			0		
	Naphthalene	1.18E-03	7.50E-06	25		
6	Trichloroethene	9.10E-03	9.10E-06	4	7.59E-03	8.00E-06
	Ethylbenzene	6.44E-03	7.80E-06	13		
	Toluene	6.68E-03	8.60E-06	72		
7	1,1,2,2-Tetrachloroethane	3.80E-04	7.90E-06	0	5.30E-04	8.60E-06
	Ethyl Ether	6.80E-04	9.30E-06	0		
8	Chlorobenzene	3.93E-03	8.70E-06	43	4.26E-03	9.33E-06
	Styrene	3.30E-03	8.00E-06	0		
	Benzene	5.50E-03	9.80E-06	75		
	Chloroform	3.39E-03	1.00E-05	0		
	Methylene Chloride	3.19E-03	1.17E-05	5		
	Total Xylene	5.25E-03	7.80E-06	42		
	Methyl mercaptan	4.18E-03		5		

1. units of HLC are (atm-m<sup>3</sup>/mol)

2. units of diffusivity are (cm<sup>2</sup>/sec)

3. units of biorate are (x 10<sup>4</sup>/sec)

## 5.4 APPLICATION OF PROCEDURES TO DEER ISLAND

### 5.4.1 SOURCES OF EMISSIONS

Major wastewater treatment facilities at Deer Island will include:

- o The North Main Pumping Station
- o Winthrop Terminal
- o South System Pumping Station
- o Grit Facilities, East and West
- o Grit Classifiers
- o Primary Effluent Screening Facilities
- o Primary Influent Channels
- o Primary Splitter Box
- o Aerated Channels
- o Primary Clarifiers
- o Secondary Splitter Box
- o Anaerobic Selector Basin
- o Aeration Basins
- o Secondary Influent Channel
- o Secondary Clarifiers
- o Secondary Sludge Pumping Station
- o Disinfection Basins
- o Outfall

Sources of odor-causing compounds and VOCs are the facilities where interfaces between wastewater and air are produced. These interfaces are produced at tank surfaces, channels, weirs, and aeration tanks. Emissions are not released, of course, from pumps and pipelines.

The emissions facilities were divided into three groups. One group includes facilities that have the potential to emit VOCs in sufficient amounts that the emissions could impact on ambient air levels. Emissions from this group were calculated and the results were used in air-quality modeling to determine the impact on ambient air quality. These facilities include

- o Grit Removal Facilities
- o Primary Splitter Box
- o Primary Clarifiers
- o Secondary Splitter Box
- o Anaerobic Selector Basin
- o Aeration Basins
- o Secondary Clarifiers
- o Disinfection Basins

The second group includes facilities that emit odor-producing compounds and VOCs in quantities high enough to require ventilation for decreasing the levels in the work environment. Air

vented from these facilities would be collected and treated before exhaust, but the small amount of VOCs released after treatment would not be included in air-quality modeling. These facilities include

- o Winthrop Terminal
- o Vent Shafts from North System Tunnels
- o Primary Screening Facilities
- o Grit Classifiers
- o Primary Influent Channel
- o Secondary Influent Channel
- o Wet Wells From South System Pumping Station
- o Secondary Sludge Pumping Station

This group also includes vent shafts from wastewater tunnels to Deer Island.

The third group includes only the outfall vent, which will have little potential for release of odor-causing compounds and VOCs. Thus exhaust would not require treatment before release to the atmosphere.

#### 5.4.2 APPLICATION OF MODELS FOR EMISSIONS

##### Grit Removal Facilities

Most of the emissions from grit removal will be from the effluent weirs controlling flow from the facilities. Emissions from the flow over the weirs will be much greater than from the surface of the grit chambers. The chambers will be covered, and the covering will greatly decrease emissions. In contrast to emissions from the weir, emissions from the water surface in the grit facilities can be disregarded. Weir formulas were used to estimate emissions from the grit facilities.

##### Primary Splitter Box

The primary splitter box will include adjustable weirs to control flow to the primary clarifiers. Weir formulas were used to estimate emissions from the primary splitter box.

##### Primary Clarifiers

Like the grit removal facilities, the primary clarifiers will be covered, and the major source of emissions will be the weirs. Weir formulas were used to estimate emissions from the primary clarifiers.

##### Secondary Splitter Box

The secondary splitter box will include adjustable weirs to control flow to the aeration tanks. Weir formulas were used to estimate emissions.

## Anaerobic Selector Basin and Aeration Tanks

Emissions from the anaerobic selectors will be small compared to the emissions from the aeration tanks and from the weirs at the end of the aeration tanks. Thus, their emissions rates were not calculated. Emissions from the aeration tanks were based on the models discussed in Section 5.2.3. Weir formulas were used to estimate emissions from the weirs.

## Secondary Clarifiers

VOCs will be emitted from the surfaces of the secondary clarifiers and from the effluent weirs. The emissions from the clarifier surfaces were included because these basins will not be covered, and the wind action on the surfaces will increase volatilization. The procedure described in Section 5.2.1 was used to calculate emissions from the clarifier surface. Weir formulas were used to calculate emissions from the weirs.

## Disinfection Basins

The emissions from the disinfection basins were calculated using the procedure described in Section 5.2.1 for emissions from tank surfaces. Emissions from the weirs at the end of the disinfection basins were not calculated. It was observed that VOCs were almost completely eliminated at the end of the disinfection basins. In fact, emissions from the disinfection basins could have been disregarded because the concentration of VOCs after the secondary clarifiers was so low.

## 5.4.3 DATA FOR EMISSIONS SOURCES

Three discrete types of data are required for the treatment systems, depending on whether the systems are being modeled as a weir, a quiescent liquid, or an aeration tank. Pertinent data required for calculating emissions are provided in Tables 5.4.3-1 and 5.4.3-2.

## 5.5 SCENARIOS EVALUATED FOR EMISSION CALCULATIONS

The Deer Island upgrade is being designed to accommodate a variety of load and flow conditions. Several distinct flow regimes exist, encompassing storm and non-storm flows in low-flow and high-flow seasons. The data assembled from the wastewater sampling programs have been split into groups consisting of minimum-, maximum-, and average-day loadings. Finally, the orientation of proposed treatment units may change with the overall treatment process. Since the number of potential scenarios derived from all possible combinations of these variables becomes unmanageable with respect to emission calculation only reasonable worst-case scenarios were evaluated.

As discussed in Section 3, the evaluation of emissions must consider two aspects of the proposed system: the expected increase in VOC emissions (determined on an annual basis); and the maximum expected ambient impacts of potentially toxic releases from the facility (determined on a 24-h basis). Because of these two main aspects of concern, all scenarios containing minimum pollutant mass loadings were removed from further consideration.

**TABLE 5.4.3-1**  
**Treatment System Physical Data**

<u>Unit</u>	<u>No. of units</u>	<u>Overall Area, m<sup>2</sup></u>	<u>Depth, m</u>	<u>Weir Length, m</u>	<u>Tailwater Depth, m</u>
Centrifugal Grit	16			43.6	3.6
Primary Clarifier	4				
Splitter	1			24.4	3.4
Weir	20			1120.0	0.5
Aeration Tank	4	37972	23.5		
Splitter	1		32.0	3.6	
Weir	4			274.3	3.6
Secondary Clarifier	4	56013	30		
Weir	4			8000.0	0.5
Disinfection	1	11576		13	

**TABLE 5.4.3-2**  
**Treatment System Operating Characteristics for Proposed Deer Island Facilities**

Unit	FlowCondition				
	Average Low GW	Average High GW	Minimum	Maximum	Max+Storm
Centrifugal Grit					
flow, m <sup>3</sup> /s	12.27	16.04	10.0	26.2	40.0
drop height, m	0.62	0.62	0.6	0.68	0.78
Primary Clarifier					
Splitter					
flow, m <sup>3</sup> /s	17.09	26.73	14.02	42.07	55.65
drop height, m	0.88	0.71	0.89	0.66	0.42
Weir					
flow, m <sup>3</sup> /s	17.09	26.73	14.02	42.07	55.65
drop height, m	0.78	0.62	0.83	0.41	0.23
Aeration Tank					
Splitter					
flow, m <sup>3</sup> /s	22.79	35.54	16.12	56.09	69.36
drop height, m	1.25	0.91	1.25	1.29	0.51
Basin					
flow, m <sup>3</sup> /s	22.79	35.54	16.12	56.09	69.36
biomass, g/l	2.0	2.0	2.0	2.0	2.0
air flow, m <sup>3</sup> /s	62.96	62.98	131.73	136.41	141.11
K <sub>L</sub> a, 1/day	85	85	164	172	179
oxygen flow, m <sup>3</sup> /s	1.37	1.37	2.86	2.96	3.07
K <sub>L</sub> a, 1/day	113	113	218	229	239
Weir					
flow, m <sup>3</sup> /s	22.79	35.54	16.12	56.09	69.36
drop height, m	0.88	0.69	0.89	0.59	0.40
Secondary Clarifier					
Weir					
flow, m <sup>3</sup> /s	17.09	26.73	14.02	42.07	47.32
drop height, m	0.73	0.53	0.79	0.33	0.15



Two flow regimes exist under average conditions: average flow during low groundwater levels, and average flow during high groundwater levels. The level of the groundwater influences the amount of clean water infiltrating the collector system and thus impacts the volume of water that must be treated. The actual load of contaminants in the influent, in terms of pounds per day, will not change between the two groundwater level regimes, but the increased infiltration during high groundwater seasons will reduce the pollutant concentrations, shorten the unit process detention times, and increase the overflow rate in the treatment system. All of these conditions will affect the rate at which pollutants are emitted.

An estimate of the annual emissions from the treatment system was obtained by performing emission calculations for the two average-flow conditions with average pollutant loadings. On the average, a low groundwater level exists eight months out of the year; a high groundwater level exists the remaining four months. Annual emissions were calculated for each of the two groundwater conditions. The overall annual emission rate for each individual constituent was then determined by calculating a weighted average of the two rates based on the amount of time each groundwater condition occurs during the year. This weighted average produces an annual average flow rate of 480 mgd, compared to 380 mgd and 670 mgd for the low and high groundwater level conditions, respectively. The total VOC emission rate was estimated using the relationship of VOCs to the sum of individual constituents as described in Section 4.4.

Maximum short-term emission rates were calculated for several different flow scenarios using maximum constituent mass loading rates. No other average conditions, other than those discussed above, were subjected to the emission calculation procedures. The minimum wastewater flow was considered because long detentions and large drops over the weirs could yield high emission rates for volatile constituents with low biodegradation rates. Minimum-flow rates would also allow more time for the constituent to escape to the atmosphere from the basins.

The maximum flow was selected to ensure that the scenario representing the maximum short-term emission rate had been analyzed. The constituent loadings added by storm runoff were also included in a calculation using normal maximum loadings at maximum normal-flow plus maximum storm water flow. Identification of these three scenarios for emission calculations was expected to yield a larger short-term emission rate than any other conceivable situation. Upon reviewing the results of each emission scenario, those expected to produce the greatest ambient impacts were subjected to the air pollutant dispersion modeling analysis described in Section 7.

## 5.6 RESULTS OF EMISSION CALCULATIONS

Emissions were calculated for existing and proposed facilities at Nut and Deer Islands the scenarios described in Section 5.5 using treatment trains consisting of air or oxygen activated sludge. Emissions from the existing treatment systems on Deer and Nut Islands were also calculated. The output generated by the computer program used provided an annual emission total for each constituent, by treatment unit, as well as the individual maximum emission rate for each constituent across the entire system. These rates represent emissions prior to control. The existing facilities on Deer Island were estimated to emit a total of 40 tons/yr

of PPL/HSL constituents; existing Nut Island facilities were estimated to emit 7 tons/yr.

The conditions representing baseline were established for the Deer Island treatment units and the Nut Island treatment units to define the major source status of the existing treatment systems. The status of the three headworks was not determined since these systems have already received construction permits. After the baseline conditions were established, the emission rates of the individual constituents in the wastewater were calculated using the procedures described in Section 5.5 of this Appendix. Based on these procedures and the data presented in Sections 4 and 5, the baseline Deer Island facilities emit a total of 40 tons/yr of individual constituents and the Nut Island facilities emit a total of 7 tons/yr.

All of the individual constituents for which emission rates were determined are considered VOCs. The total VOC emission rate, however, will exceed the sum of emission rates for the individual constituents because there are many other organic compounds in the wastewater that can be volatilized. Most of these VOCs will not be potentially toxic, but they will contribute to the total baseline emission rate (as well as the projected emission increases) and thus will affect the decisions regarding preconstruction approval. At this point, limited data exist on total VOCs and their relationship to the individual constituents present in liquid and air streams.

Air emissions data generated at the three headworks treatment facilities were examined to estimate the total VOC emission rate. Unfortunately, the data were inconclusive with respect to any clear relationship between individual constituents and total VOCs. In reviewing the data generated for total VOCs and individual constituents, the only conclusion derived was that the ratio of VOCs and the sum of individual constituents were between 20 and 50. No statistical correlation was found, however, between the two parameters. Nevertheless, the data provided an indication that the existing facilities on Deer and Nut Islands should be considered as major existing sources of VOCs, with emissions ranging between 810 and 2000 tons/yr at Deer Island and between 140 and 350 tons/yr at Nut Island. Additional study is needed to more accurately estimate the total VOC load from existing and proposed facilities.

The results obtained for the proposed facilities at average flow and load conditions are presented in Table 5.6-1 for the air system and in Table 5.6-2 for the oxygen system. The tables give the individual annual uncontrolled emission rates for all constituents by source and in total. Comparison of the tables shows that the annual uncontrolled emissions from the oxygen system will be slightly less than from the air system. This is because the volume of oxygen used in the aeration system is only about one-fortieth of that for air.

The maximum short-term uncontrolled emission rates for each individual constituent, by source, are provided in Tables 5.6-3 and 5.6-4 for the air and oxygen systems, respectively. Like the annual rates, the short-term emission rates show that the activated sludge system with oxygen generates fewer emissions than the system with air for aeration. These short-term emission rates (after a control factor has been applied) are calculated for comparison with AALs.

The distribution of emissions by treatment unit indicates that a majority of the releases occur prior to the aeration basin. As discussed earlier, the major cause prior to the aeration basin

**TABLE 5.6-1**  
**Annual Uncontrolled Emission Estimates For Individual Constituents Released From**  
**The Proposed Deer and Nut Island Treatment Facilities -- Air Feed System at Deer**  
**Island. (tons/yr)**

Constituent	Nut Island			Deer Island				Total
	Distr Chan.	Grit Weir	Total	Primary Area	Aeration Area	Final Clarifier	Disinfection	
Benzene	0.00	0.01	0.01	0.94	0.37	0.00	0.00	1.31
Chloroform	0.00	0.02	0.02	1.29	1.17	0.04	0.00	2.50
Ethylbenzene	0.00	0.03	0.03	1.96	1.41	0.00	0.00	3.37
Methylene chloride	0.00	0.13	0.13	7.64	3.27	0.00	0.00	10.91
Tetrachloroethene	0.00	0.06	0.06	3.37	1.48	0.00	0.00	4.85
Toluene	0.00	0.05	0.05	4.12	1.90	0.00	0.00	6.02
Trans-dichloroethene (1,2)	0.00	0.03	0.03	2.02	0.90	0.00	0.00	2.92
1,1,1-Trichloroethane	0.00	0.04	0.04	2.97	4.29	0.02	0.00	7.28
Trichloroethene	0.00	0.04	0.04	2.46	2.65	0.00	0.00	5.11
Trichlorofluoromethane	0.00	0.05	0.05	2.70	1.40	0.00	0.00	4.10
Styrene	0.00	0.04	0.04	1.63	1.46	0.04	0.00	3.13
Acetone	0.00	0.01	0.01	0.88	0.72	0.03	0.00	1.63
2-Butanone	0.00	0.00	0.00	0.18	0.09	0.00	0.00	0.27
Total xylenes	0.00	0.08	0.08	4.66	1.81	0.00	0.00	6.47
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	1.78	0.87	0.06	0.01	2.72
Methyl mercaptan	0.00	0.09	0.09	3.67	3.32	0.12	0.01	7.12
Bromomethane	0.00	0.08	0.08	4.44	5.00	0.06	0.00	9.50
2-Propanone, 1-fluoro	0.00	0.00	0.00	1.14	1.90	0.02	0.00	3.06
Carbon disulfide	0.00	0.04	0.04	1.45	1.95	0.01	0.00	3.41
2-Butanone, 3-methoxy, 3-methyl	0.00	0.00	0.00	0.53	0.91	0.03	0.00	1.47
Ethyl ether	0.00	0.00	0.00	0.10	0.22	0.05	0.01	0.38
Phenol	0.00	0.00	0.00	0.03	0.06	0.01	0.00	0.10
Naphthalene	0.00	0.10	0.10	2.27	0.91	0.00	0.00	3.18
Chlorobenzene	0.00	0.04	0.04	2.44	0.92	0.00	0.00	3.36
o-Cresol	0.00	0.00	0.00	0.54	0.19	0.00	0.00	0.73
p-Cresol	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
1,2-Dichlorobenzene	0.00	0.10	0.10	3.27	2.72	0.12	0.01	6.12
Benzenamine	0.00	0.00	0.00	1.16	0.97	0.06	0.00	2.19
Hexone (MIBK)	0.00	0.00	0.00	0.07	0.11	0.07	0.01	0.26
Benzyl alcohol	0.00	0.00	0.00	0.08	0.06	0.02	0.00	0.16
Pentane, 3-meth,								
2,2,4-trimethyl	0.00	0.03	0.03	1.09	0.90	0.04	0.00	2.03
Dimethyl disulfide	0.00	0.00	0.00	0.38	0.32	0.02	0.00	0.72
Dimethyl sulfide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>TOTAL</b>	<b>0.01</b>	<b>1.05</b>	<b>1.06</b>	<b>61.25</b>	<b>44.24</b>	<b>0.81</b>	<b>0.09</b>	<b>106.39</b>

TABLE 5.6-2

Annual Uncontrolled Emission Estimates For Individual Constituents Released From  
The Proposed Deer and Nut Island Treatment Facilities -- Oxygen Feed System.  
(tons/yr)

Constituent	Nut Island			Deer Island				
	Distr Chan	Grit Weir	Total	Primary Area	Aeration Area	Final Clarifier	Disinfect- tion	Total
Benzene	0.00	0.01	0.01	0.94	0.36	0.00	0.00	1.30
Chloroform	0.00	0.02	0.02	1.29	0.95	0.05	0.00	2.29
Ethylbenzene	0.00	0.03	0.03	1.96	1.55	0.00	0.00	3.51
Methylene chloride	0.00	0.13	0.13	7.64	2.87	0.00	0.00	10.51
Tetrachloroethene	0.00	0.06	0.06	3.37	1.27	0.00	0.00	4.64
Toluene	0.00	0.05	0.05	4.12	1.99	0.00	0.00	6.11
Trans-dichloroethene (1,2)	0.00	0.03	0.03	2.02	0.72	0.00	0.00	2.74
1,1,1-Trichloroethane	0.00	0.04	0.04	2.97	2.34	0.12	0.01	5.44
Trichloroethene	0.00	0.04	0.04	2.46	2.86	0.00	0.00	5.32
Trichlorofluoromethane	0.00	0.05	0.05	2.70	0.98	0.00	0.00	3.68
Styrene	0.00	0.04	0.04	2.21	1.63	0.09	0.01	3.94
Acetone	0.00	0.01	0.01	0.40	0.22	0.00	0.00	0.62
2-Butanone	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.15
Total xylenes	0.00	0.08	0.08	6.28	2.33	0.00	0.00	8.61
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	0.18	0.23	0.08	0.01	0.50
Methyl mercaptan	0.00	0.09	0.09	4.90	3.62	0.20	0.01	8.73
Bromomethane	0.00	0.08	0.08	4.29	3.28	0.14	0.01	7.72
2-Propanone, 1-fluoro	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.06
Carbon disulfide	0.00	0.04	0.04	1.95	1.54	0.08	0.01	3.58
2-Butanone, 3-methoxy, 3-methyl	0.00	0.00	0.00	0.03	0.03	0.03	0.01	0.10
Ethyl ether	0.00	0.00	0.00	0.12	0.16	0.06	0.01	0.35
Phenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphthalene	0.00	0.10	0.10	3.08	1.18	0.00	0.00	4.26
Chlorobenzene	0.00	0.04	0.04	2.17	0.81	0.00	0.00	2.98
o-Cresol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-Cresol	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
1,2-Dichlorobenzene	0.00	0.10	0.10	4.43	3.42	0.19	0.01	8.05
Benzenamine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexone (MIBK)	0.00	0.00	0.00	0.09	0.11	0.09	0.02	0.31
Benzyl alcohol	0.00	0.00	0.00	0.08	.05	0.00	0.00	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.00	0.03	0.03	1.44	1.11	0.06	.00	2.61
Dimethyl disulfide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>TOTAL</b>	<b>0.01</b>	<b>1.05</b>	<b>1.06</b>	<b>61.25</b>	<b>35.68</b>	<b>1.20</b>	<b>0.11</b>	<b>98.25</b>



Table 5.6-3

Maximum Short-term Uncontrolled Emission Estimates for Individual Constituents Under Various Flow and Maximum Load Conditions on Deer and Nut Islands -- Air Feed System. (lb/day)

Constituent	Nut Island		Deer Island	
	Max Flow	Min Flow	Max Flow	Max Strm Flow
Benzene	0.23	11.32	8.44	13.22
Chloroform	0.31	32.50	24.42	30.14
Ethylbenzene	0.55	43.66	39.79	35.60
Methylene chloride	5.23	182.34	142.37	96.04
Tetrachloroethene	1.29	71.70	55.92	71.13
Toluene	8.08	93.15	73.15	57.07
Trans-dichloroethene (1,2)	0.64	31.10	25.41	21.30
1,1,1-Trichloroethane	0.76	80.74	79.31	88.65
Trichloroethene	0.98	68.55	68.22	81.84
Trichlorofluoromethane	0.51	34.81	29.95	45.72
Styrene	0.50	41.77	31.44	40.84
Acetone	0.21	11.46	7.34	5.74
2-Butanone	0.08	2.20	1.41	1.20
Total xylenes	1.81	139.08	102.22	93.93
1,1,2,2-Tetrachloroethane	0.03	8.42	3.89	2.94
Methyl mercaptan	1.02	107.18	80.47	98.27
Bromomethane	1.36	97.16	101.17	93.76
2-Propanone, 1-fluoro	0.01	0.34	0.32	0.21
Carbon disulfide	0.49	43.62	42.83	67.61
2-Butanone, 3-methoxy, 3-methyl	0.01	1.04	0.45	0.57
Ethyl ether	0.03	5.56	2.57	3.24
Phenol	0.00	0.05	0.03	0.02
Naphthalene	2.11	64.86	4.70	29.56
Chlorobenzene	0.50	28.39	20.82	19.08
o-Cresol	0.00	0.05	0.03	0.03
p-Cresol	0.00	0.05	0.03	0.03
1,2-Dichlorobenzene	1.99	94.37	67.06	43.68
Benzenamine	0.00	0.05	0.03	0.03
Hexone (MIBK)	0.03	4.32	1.88	2.05
Benzyl alcohol	0.03	1.51	0.97	0.89
Pentane, 3-meth,				
2,2,4-trimethyl	0.33	22.22	15.80	20.26
Dimethyl disulfide	0.00	0.03	0.01	0.02
Dimethyl sulfide	0.00	0.10	0.05	0.04
TOTAL	29.12	1323.70	1032.53	1064.73

Table 5.6-4

Maximum Uncontrolled Short-term Emission Estimates for Individual Constituents Under Various Flow and Maximum Load Conditions on Deer and Nut Islands -- Oxygen Feed System. (lb/day)

Constituent	Nut Island		Deer Island	
	Max Flow	Min Flow	Max Flow	Max Strm Flow
Benzene	0.23	11.28	8.37	12.98
Chloroform	0.31	28.81	20.65	22.51
Ethylbenzene	0.55	45.12	42.13	38.59
Methylene chloride	5.23	173.39	128.66	79.35
Tetrachloroethene	1.29	67.67	49.13	55.32
Toluene	8.08	94.80	75.89	60.85
Trans-dichloroethene (1,2)	0.64	28.75	21.27	15.14
1,1,1-Trichloroethane	0.76	66.39	47.66	38.66
Trichloroethene	0.98	70.19	70.81	85.98
Trichlorofluoromethane	0.51	30.68	22.74	27.67
Styrene	0.50	37.02	26.59	30.49
Acetone	0.21	11.40	7.27	5.64
2-Butanone	0.08	2.19	1.40	1.18
Total xylenes	1.81	138.14	100.60	90.85
1,1,2,2-Tetrachloroethane	0.03	5.02	2.57	1.72
Methyl mercaptan	1.02	74.66	53.49	57.68
Bromomethane	1.36	86.30	64.71	43.70
2-Propanone, 1-fluoro	0.01	0.27	0.27	0.17
Carbon disulfide	0.49	35.87	25.73	29.48
2-Butanone, 3-methoxy, 3-methyl	0.01	0.85	0.39	0.46
Ethyl ether	0.03	3.31	1.70	1.89
Phenol	0.00	0.05	0.03	0.02
Naphthalene	2.11	64.62	46.60	29.04
Chlorobenzene	0.50	28.20	20.50	18.47
o-Cresol	0.00	0.05	0.03	0.03
p-Cresol	0.00	0.05	0.03	0.03
1,2-Dichlorobenzene	1.99	89.41	63.01	39.09
Benzenamine	0.00	0.05	0.03	0.03
Hexone (MIBK)	0.03	3.52	1.60	1.68
Benzyl alcohol	0.03	1.50	0.96	0.88
Pentane, 3-meth,				
2,2,4-trimethyl	0.33	21.05	14.85	18.13
Dimethyl disulfide	0.00	0.03	0.01	0.02
Dimethyl sulfide	0.00	0.10	0.05	0.04
TOTAL	29.12	1220.77	919.75	807.77



is turbulence as wastewater flows over weirs.

The proposed treatment facility at Deer Island will include covers to prevent uncontrolled release of air pollutants. The covers will be installed on all portions of the facility between and including the centrifugal grit chambers and the aeration tank effluent weirs. The emissions from each of these treatment systems will be collected and delivered to an odor/VOC control system before discharge to the atmosphere. Several independent systems will be operated for control of offgas streams from various treatment units. Details on the control system are provided in Section 6.

For the purpose of providing a conservative estimate, a control efficiency of 85 percent through the emission control system has been assumed for all constituents except the reduced sulfur species; 95 percent control has been assumed for these constituents. Based on these removal efficiencies, the annual controlled emission rate is 15.3 tons/yr of individual constituents for the air system and 14.7 tons/yr of individual constituents for the oxygen system. Table 5.6-5 presents the estimated annual release rate for each constituent after control from the proposed facilities and from the existing facilities. The maximum short-term controlled release rates, by source, for all other scenarios are provided in Table 5.6-6 for the air system and Table 5.6-7 for the oxygen system.

As discussed in Section 3, the level of control implemented for the proposed system is dependent on the magnitude of VOC emission increases above a baseline emission rate. Based on the relationship discussed between VOCs and individual constituents, the VOC baseline emission rate is estimated to be between 810 and 2000 tons/yr for Deer Island and between 140 and 350 tons/yr for Nut Island. Applying this same relationship (that total VOCs are equal to 20 to 50 times the sum of the individual constituents) yields an estimated controlled VOC emission rate of between 306 and 766 tons/yr for the proposed air system on Deer Island, between 293 and 733 tons/yr for the proposed oxygen system on Deer Island, and between 21.0 and 53.0 tons/yr for the proposed facilities on Nut Island.

Because comparison of proposed to existing annual VOC emissions yields a net reduction from Deer Island and Nut Island baseline levels, the control systems required for both Deer and Nut Island facilities must represent BACT. Comparison of the average existing and maximum short-term emission rates provided in Tables 5.6-6 and 5.6-7 shows that the maximum short-term emission rate of each individual constituent released by the proposed system, with a few minor exceptions, is also less than the individual rates at baseline conditions.

Although the uncontrolled emissions are greater from the proposed facilities than from the existing facilities, the need to apply BACT to the proposed facilities produces a net reduction in actual emissions for both total VOCs and most individual constituents. This indicates that regulatory requirements are met with the use of BACT as opposed to LAER, and that the VOC emissions from the proposed facilities are not required to be offset. Final selection of the odor/VOC control system, however, is also dependent on the ambient impact of the individual constituents. This aspect is discussed in Section 7.

**Table 5.6-5**  
**Comparison of Annual Controlled Constituent Emission Estimates for the Existing and Proposed Treatment Systems on Deer and Nut Islands. (tons/yr)**

Constituent	Deer Island			Nut Island	
	Existing	Proposed oxygen	air	Existing	Proposed
Benzene	0.64	0.20	0.20	0.09	0.01
Chloroform	0.91	0.39	0.41	0.13	0.02
Ethylbenzene	1.38	0.53	0.50	0.25	0.03
Methylene chloride	5.16	1.58	1.64	0.80	0.13
Tetrachloroethene	2.26	0.70	0.73	0.37	0.06
Toluene	3.10	0.92	0.90	0.30	0.05
Trans-dichloroethene (1,2)	1.37	0.41	0.44	0.23	0.03
1,1,1-Trichloroethane	2.15	0.92	1.11	0.27	0.04
Trichloroethene	1.68	0.80	0.77	0.26	0.04
Trichlorofluoromethane	1.97	0.55	0.61	0.30	0.05
Styrene	1.47	0.64	0.71	0.23	0.04
Acetone	0.43	0.13	0.09	0.10	0.01
2-Butanone	0.00	0.02	0.02	0.08	0.00
Total xylenes	4.65	1.29	1.30	0.46	0.08
1,1,2,2-Tetrachloroethane	0.14	0.13	0.18	0.08	0.00
Methyl mercaptan	2.84	0.59	0.63	0.60	0.09
Bromomethane	2.80	1.30	1.50	0.48	0.08
2-Propanone, 1-fluoro	0.02	0.07	0.03	0.03	0.00
Carbon disulfide	1.25	0.24	0.25	0.22	0.04
-Butanone, 3-methoxy, 3-methyl	0.02	0.06	0.04	0.01	0.00
Ethyl ether	0.09	0.10	0.12	0.02	0.00
Phenol	0.00	0.02	0.00	0.04	0.00
Naphthalene	1.29	0.64	0.64	0.58	0.10
Chlorobenzene	1.32	0.45	0.45	0.22	0.04
o-Cresol	0.00	0.00	0.00	0.00	0.00
p-Cresol	0.00	0.00	0.00	0.05	0.00
1,2-Dichlorobenzene	2.36	1.31	1.41	0.60	0.10
Benzenamine	0.00	0.07	0.00	0.00	0.00
Hexone (MIBK)	0.08	0.11	0.14	0.02	0.00
Benzyl alcohol	0.08	0.04	0.02	0.04	0.00
Pentane, 3-meth,					
2,2,4-trimethyl	0.81	0.43	0.46	0.16	0.03
Dimethyl disulfide	0.00	0.02	0.00	0.00	0.00
Dimethyl sulfide)	0.00	0.00	0.00	0.00	0.00
TOTAL	40.40	14.66	15.31	7.01	1.06

Table 5.6-6

Short-term Controlled Constituent Emission Estimates Under Various Flow and Load Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -- Air System. (lb/day)

Constituent	Nut Island		Deer Island			
	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.70	1.27	1.98
Chloroform	0.71	0.31	4.98	5.09	3.98	4.92
Ethylbenzene	1.35	0.55	7.58	6.55	5.97	5.34
Methylene chloride	4.36	5.23	28.27	27.35	21.57	14.65
Tetrachloroethene	2.02	1.29	12.40	10.76	8.39	10.67
Toluene	1.64	8.08	17.01	13.97	10.97	8.56
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.66	3.81	3.19
1,1,1-Trichloroethane	1.46	0.76	11.78	12.12	12.05	13.48
Trichloroethene	1.45	0.98	9.21	10.28	10.23	12.28
Trichlorofluoromethane	1.65	0.51	10.82	5.22	4.49	6.86
Styrene	1.25	0.50	8.03	6.54	5.13	6.67
Acetone	0.53	0.21	2.37	1.72	1.10	0.86
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.86	15.33	14.09
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	2.06	0.86	0.71
Methyl mercaptan	3.29	1.02	15.58	3.73	3.15	3.86
Bromomethane	2.61	1.36	15.35	14.57	15.22	14.11
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.14	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.18	2.23	3.53
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.43	0.15	0.22
Ethyl ether	0.11	0.03	0.47	1.36	0.57	0.78
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.73	7.10	4.43
Chlorobenzene	1.23	0.50	7.23	4.26	3.12	2.86
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.44	11.26	7.36
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.78	0.61	0.80
Benzyl alcohol	0.19	0.03	0.43	0.23	0.15	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.88	0.33	4.46	3.63	2.65	3.42
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.03	0.01	0.01
TOTAL	38.43	29.12	221.37	186.77	151.71	146.07

**Table 5.6-7**  
**Actual Short-term Constituent Emission Estimates Under Various Flow and Load**  
**Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands --**  
**Oxygen System. (lb/day)**

Constituent	Nut Island		Deer Island			
	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.69	1.26	1.95
Chloroform	0.71	0.31	4.98	4.80	3.51	3.87
Ethylbenzene	1.35	0.55	7.58	6.77	6.32	5.79
Methylene chloride	4.36	5.23	28.27	26.01	19.57	12.21
Tetrachloroethene	2.02	1.29	12.40	10.15	7.37	8.30
Toluene	1.64	8.08	17.01	14.22	11.38	9.13
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.31	3.19	2.27
1,1,1-Trichloroethane	1.46	0.76	11.78	10.92	8.05	6.58
Trichloroethene	1.45	0.98	9.21	10.53	10.62	12.90
Trichlorofluoromethane	1.65	0.51	10.82	4.60	3.41	4.15
Styrene	1.25	0.50	8.03	6.16	4.52	5.24
Acetone	0.53	0.21	2.37	1.71	1.09	0.85
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.72	15.09	13.63
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	1.64	0.67	0.53
Methyl mercaptan	3.29	1.02	15.58	6.50	4.92	5.47
Bromomethane	2.61	1.36	15.35	13.78	10.73	7.31
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.13	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.38	1.83	2.14
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.40	0.14	0.20
Ethyl ether	0.11	0.03	0.47	1.08	0.44	0.58
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.69	0.70	4.36
Chlorobenzene	1.23	0.50	7.23	4.23	3.07	2.77
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.00	10.75	6.73
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.67	0.57	0.74
Benzyl alcohol	0.19	0.03	0.43	0.23	0.14	0.13
Pentane, 3-meth,						
2,2,4-trimethyl	0.88	0.33	4.46	3.53	2.53	3.12
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.01	0.01	0.01
TOTAL	38.43	29.12	221.37	183.22	132.21	121.24

## 5.7 SCENARIOS SELECTED FOR AMBIENT IMPACT ASSESSMENT

The oxygen system results presented in the preceding Section indicate that the scenario using maximum load and minimum flow conditions produces the greatest short-term emission rate for all but two constituents (benzene and trichloroethene). Review of the detailed emission results included as attachment I indicates the benzene will be released in greater amounts during storm flows from the grit chamber and trichloroethene from the aeration tanks. Both of these pollutants were subjected to screening level analysis in Section 7. Because the stack conditions for the air pollution control system will not vary between flow and load scenarios, maximum ambient air impacts can be estimated by performing dispersion calculations only for the maximum load, minimum flow scenario. A discussion of the methods and results of performing the dispersion calculations is provided in Section 7.

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## 6.0 EVALUATION OF SYSTEMS FOR CONTROLLING EMISSIONS

This section reviews available technologies for both odor and VOC abatement and identifies technologies appropriate for use at Deer and Nut Islands. Technologies that should be subjected to a detailed analysis for incorporation in the final design are identified, and include pollutant removal or control from the wastewater before the pollutants are released to the atmosphere, and collection and control of air streams.

### 6.1 CONTROL TECHNOLOGIES FOR LIQUID STREAMS

The potential for release of odors from wastewater can be decreased by treating the liquid stream. Some of the methods available include chemical oxidation, raising the oxidation/reduction potential, and pH control.

Chemical oxidation is obtained by adding chlorine, ozone, hydrogen peroxide, or potassium permanganate to wastewater. These chemicals can inhibit the growth of bacteria that produce odorous compounds and can also oxidize the compounds. Chlorine, for example, can oxidize sulfide to sulfate.

Oxidation/reduction control can be achieved by adding dissolved oxygen or nitrate to wastewater. With oxygen or nitrate present, sulfide will not be produced.

Lime or caustic soda can be added to wastewater to raise the pH high enough (pH 8 or more) so that hydrogen sulfide will not be released.

These systems have been used in wastewater systems and treatment plants. However, to be conservative, in analyses of emissions from the Deer Island plant and the Nut Island headworks, the use of chemicals to decrease the potential for odors was not considered. This means that the equipment to control odors would be adequate without addition of chemicals.

### 6.2 CONTROL TECHNOLOGIES FOR AIR STREAMS

Odor-producing compounds and VOCs in air streams are controlled by collecting the air streams and treating them before release to the atmosphere. Available treatment technologies include: ozonation, wet scrubbing with a mist chamber, wet scrubbing with a packed tower, carbon adsorption, incineration, and condensation. Some processes are applicable for both odor and VOC control; some are applicable for either one or the other, but not for both.

#### 6.2.1 OZONATION

In an ozonation system, odorous air is contacted with ozone in a long, baffled chamber to promote mixing and oxidation of the odorous compounds. A typical ozonation system produces ozone from clean dry air and diffuses the ozone into a contact chamber where the ozone oxidizes the odorous compounds.

To date, the use of ozone systems has been limited to odor control, rather than VOC control. Based on past operating experience, ozone systems have not proven to be effective for odor control. Ozone manufacturers originally promoted the use of ozone in odor control systems because ozone rapidly oxidizes many odorous compounds in the aqueous phase. In the gaseous phase, however, ozone systems oxidize only a small portion of the odorous compounds present. Instead of oxidizing the others, ozone simply masks their odors. When the exhaust from an ozone system is dispersed from the source, the ozone can degrade to oxygen and the original odors will reappear. If too much ozone is added, high levels of unreacted ozone in the exhaust can promote odor complaints because ozone has a sharp, acrid smell. It may be a health hazard, since ozone is toxic at concentrations above 1 ppm.

## 6.2.2 WET SCRUBBING

Control of gaseous contaminants can be accomplished by liquid scrubbing. In this method, a contaminated gas stream is brought into contact with a scrubbing liquid, allowing contaminant gases to be absorbed into the liquid. The cleaned gas is then separated from the contaminated liquid, which may be collected and treated. The rate of mass transfer of the contaminating gas into the scrubbing liquid is proportional to the gas-liquid interface surface area. Scrubbing units are therefore designed to provide large liquid surface areas. Typical unit designs include packed towers, spray towers, mist chambers, and venturi absorbers.

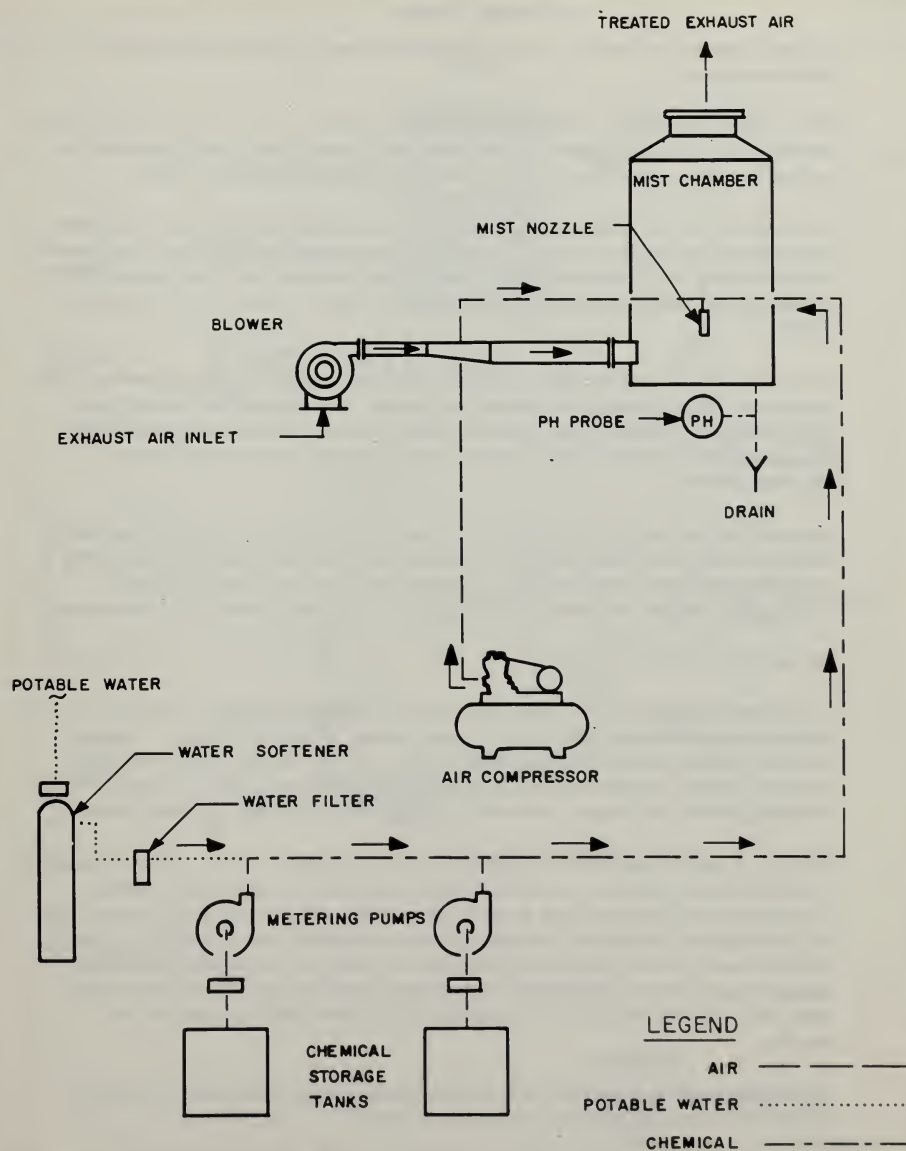
The efficiency of wet scrubbers can be enhanced by using caustic soda. The caustic soda increases the pH of the solution to increase solubility of hydrogen sulfide.

Scrubbing is very effective for removing odors because of the high solubility of hydrogen sulfide in high-pH solutions. Scrubbing is less effective, however, in removing VOCs. VOCs are generally less soluble, and, because of their very low concentration in exhaust air streams from wastewater treatment processes, significant mass transfer of the organics from the gas to a scrubber liquid is difficult to obtain. So, for both odor and VOC control, a wet scrubber would require a downstream polishing component to control the organic component.

### Mist Chambers

One of the most widely used configurations for wet scrubbing are mist chambers. (See Figure 6.2.2-1.)

Mist chambers produce a fine aerosol mist or fog through which odorous gases are passed. Compressed air and the oxidizing/neutralizing liquid are introduced through nozzles designed to produce a very fine mist (5 to 10 microns), which produces a very large surface area for transfer between phases. The treated air exits from the top of the chamber, and the liquid drains from the bottom. With a mist chamber, there is no recirculation of caustic soda solution.



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FIGURE 6.2.2-1  
SCHEMATIC DIAGRAM OF  
MIST - CHAMBER SCRUBBER

To prevent blockage of the fine nozzles, softened potable water must be used to prepare the chemical solutions.

Mist chambers are widely used in industrial applications, where odors can be very severe. Mist chambers have also been installed at some municipal wastewater plants. Their installation has resulted in effective odor removal at many wastewater treatment plants.

Advantages of the mist chamber when compared to a packed-bed scrubber (which is described below) include: no packing or chemical recirculation; lower pressure drop through the chamber; and high surface area of the small mist droplets and long detention time in the chamber which increases the probability that odorous air molecules will come in contact with the scrubbing chemical.

Some of the disadvantages include complexity, larger space requirements and maintenance of air compressors, water softeners and chemical feed systems. Mist chambers are typically larger than packed towers because of the increased detention time used, and the mist nozzles require frequent cleaning to remove chemical deposits caused by the scrubbing solution and the oxidation reactions.

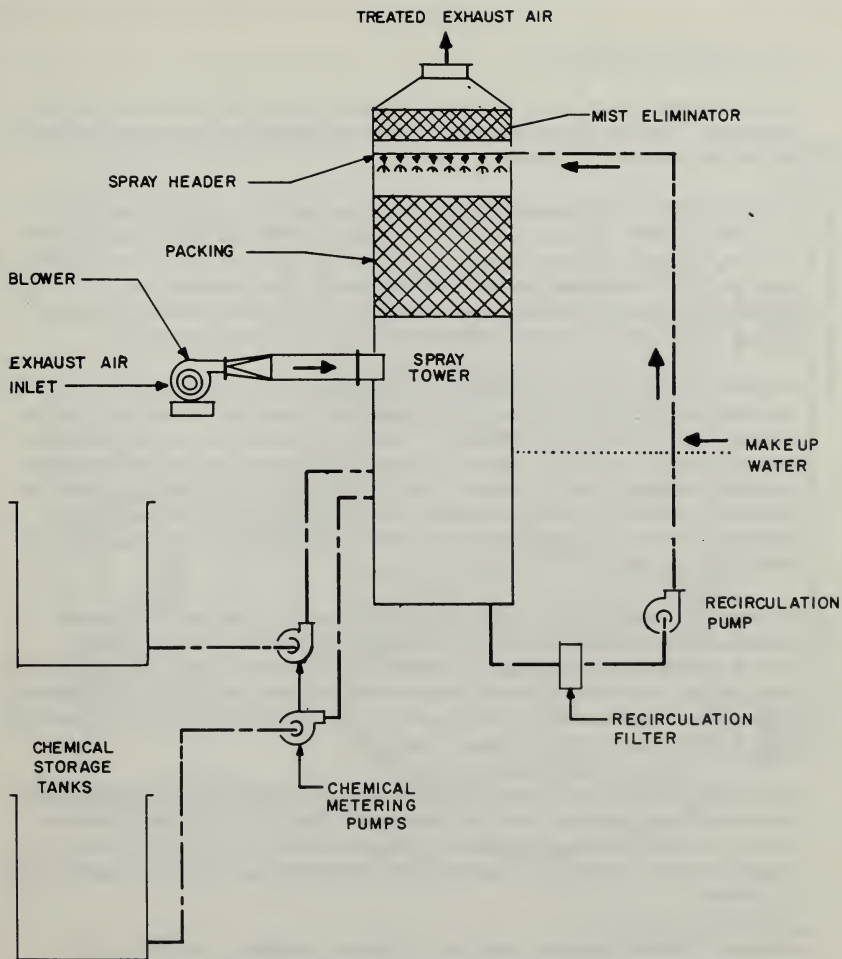
Because of the low solubility of VOCs in scrubbing liquid, scrubbing is not usually considered effective for removing VOCs. However, recent work done with mist chambers at composting operations shows high removals of VOCs. These surprising results might be attributed to surface effects allowing for removals much higher than calculated by Henry's law relationships.

#### Packed Tower

Packed tower scrubbers are filled with plastic media to create turbulence and increase interface area between the liquid and the air being treated. (See Figure 6.2.2-2.) In the tower, the odorous air and chemical solution are contacted in a fiberglass spray tower. A scrubbing liquid is recirculated from a sump at the base of the tower. Often, make-up chemicals are added to the sump to revive the potency of the recirculated scrubbing liquid.

There are numerous packed tower scrubbing systems at wastewater treatment plants. An advantage of the packed tower scrubbers is its smaller space requirements than that for mist chambers. The system is also somewhat easier to operate and maintain, and has a good performance record for removing odors (particularly from reduced sulfur compounds) from airstreams at wastewater treatment plants. It is important that all water and chemicals be removed from the scrubber exhaust if the scrubber is followed by a carbon system, since the larger droplets of the packed tower are more easily removed in a mist eliminator than much smaller droplets of a mist chamber.

Disadvantages when compared to a mist chamber include a higher pressure drop through the packing and a somewhat lower efficiency for odor control.



#### LEGEND

POTABLE WATER .....

CHEMICAL -----



### 6.2.3 CARBON ADSORPTION

Granular activated-carbon systems have been through many years of refinement and technical development. They also have good operating records at wastewater treatment plants, and can be used for both odor and VOC control.

Carbon adsorption systems typically consist of beds of activated carbon ranging from about 24 to 48 inches in depth. (See Figure 6.2.2-3.) Air enters the vessel and flows through the bed where the VOCs and odor-causing compounds are adsorbed onto the carbon. After adsorption, the treated air is discharged through a stack to the atmosphere. Once the carbon bed is saturated, regeneration of the carbon is required by one of two methods: on-site regeneration with low pressure steam, or off-site regeneration involving total carbon replacement.

Adsorption of VOCs onto activated carbon is an accepted process for control of low concentrations of VOCs in air streams. Carbon adsorption systems (with unique configurations and operating procedures) are available from a number of manufacturers. Initially, carbon adsorption systems were used by industry to recover solvents from air streams containing high solvent concentrations. Recently, however, these systems have also been applied to remove low concentration VOCs from exhaust air streams. Several manufacturers of carbon adsorption systems have systems in operation which decrease VOC concentrations in an exhaust stream to below 5 ppm by volume.

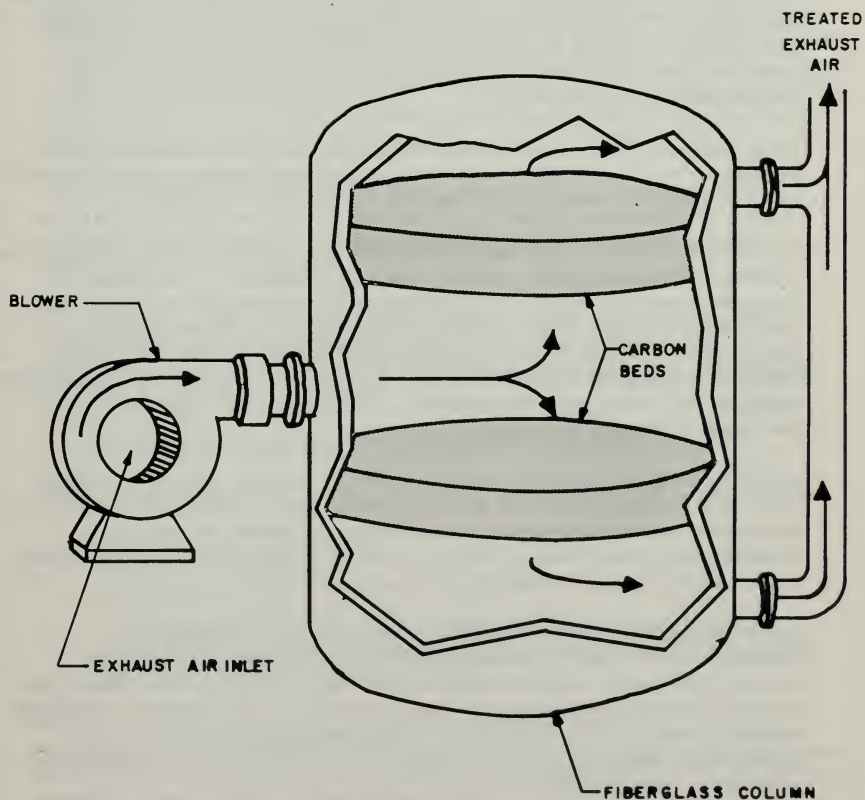
For odor control, a proprietary activated carbon that is specifically designed for removal of hydrogen sulfide is available. The carbon is impregnated with sodium hydroxide, which chemically reacts with and neutralizes any hydrogen sulfide in the gas stream. The impregnated carbon can also remove large, nonpolar molecules such as organic hydrocarbons, by adsorbing or trapping these molecules within the carbon pores. Thus, odorous compounds can be removed by one of two mechanisms: chemical reaction or adsorption.

A new process involving the injection of ammonia into a gas stream entering an activated carbon bed is being investigated at the Owl's Head plant in New York City. The ammonia acts as a catalyst in a series of reactions, transforming hydrogen sulfide to elemental sulfur. The use of small volumes of ammonia increases the amount of sulfur that can be adsorbed before the bed is regenerated.

Advantages of carbon adsorption include ease of operation, reliability in controlling a wide range of odors, and the capability of removing VOCs in addition to odors. The disadvantages include high head loss through the adsorber, and carbon regeneration or replacement costs. Also, operating problems can occur in applications with high moisture contents.

Carbon can be thermally reactivated on- or off-site, or chemically regenerated onsite. To extend the life of a carbon bed, carbon scrubbers are typically used upstream of carbon adsorbers to remove the majority of odors, leaving the carbon as a polishing unit. The regeneration process produces a waste, either gaseous or liquid, that requires treatment or disposal.





## 6.2.4 INCINERATION

Incineration is commonly used for VOC emission control and is quite capable of achieving a very high degree of VOC destruction. Various forms of incineration have been applied including flame, thermal, and catalytic incineration. Most incinerator manufacturers state that their systems are capable of reducing VOC emissions by 90 to 95 percent, even with low VOC concentrations in the inlet air stream.

Flame incineration is often used to remove VOC emissions when high concentrations support combustion. VOC concentrations in exhaust air streams from wastewater treatment processes are well below the lower combustion limit. Thus flame incineration is not practical.

Thermal incineration involves elevating the VOC-laden air temperature to 1400 to 1500 deg F and providing sufficient residence time to oxidize the organic contaminants. VOC-laden air is first passed through heat exchangers and preheated by the combustion gases exiting the unit. The process of preheating the air increases the thermal efficiency of the incineration by reducing fuel consumption. The air is then heated to 1400 deg F by auxiliary fuel in the combustion chamber, where the VOCs are oxidized. The hot exhaust gas passes through the heat exchangers and is discharged to the atmosphere. A secondary heat exchanger may be located downstream for additional heat recovery.

Catalytic incineration is sometimes used for VOC emission reduction. The catalyst increases the rate of oxidation by adsorbing the VOCs on its surface, thereby allowing the VOC-laden air to be oxidized at a lower temperature. Typical oxidation temperatures for catalytic incinerators range from 550 deg to 750 deg F. Catalysts can either be a precious metal coating on a ceramic structure or a fluidized bed of non-precious metal.

Catalytic incinerators cost more than thermal incinerators, but fuel consumption is significantly less. The primary disadvantage of catalytic incineration is the potential for poisoning of the catalyst. Chemicals known to poison catalysts include chlorine, fluorine, and phosphorus, as well as metals such as lead, zinc, and mercury. VOCs emitted from wastewater treatment processes vary considerably and the risk of catalyst poisoning is great. For this reason, catalytic incineration systems are usually not used for controlling VOC emissions from wastewater treatment processes.

## 6.2.5 CONDENSATION

Another technique for removal of gaseous VOC contaminants from an air stream utilizes the principle of condensation. In this method, the gas stream is cooled below the dew point of water and organic constituents, and the liquid is condensed and collected. It is necessary to have a vapor with a high dew point and high concentrations of contaminants for this method to be practical. In addition, this method is economically feasible only in situations where the recovery of the contaminant is profitable. Therefore, this method is not a practical alternative for control of the air streams at wastewater treatment plants.

## 6.2.6 SUMMARY OF CONTROL TECHNOLOGIES FOR AIR STREAMS

Several control systems are in common use for decreasing the concentration of odor-producing compounds and VOCs in gas streams. Of these, the most reliable system to control both odors and VOCs in air streams from wastewater treatment plants is wet scrubbing followed by activated carbon. Wet scrubbing would be used to remove odor-causing compounds, and the off-gas from the scrubbers would be directed to carbon adsorbers where residual hydrogen sulfide as well as VOCs would be removed. The overall removal efficiency for the system would be 95 to 99 percent for hydrogen sulfide and other reduced sulfur species, and around 85 percent for VOCs.

For cost purposes and for preliminary site layouts, single-stage wet scrubbing followed by carbon adsorption has been used. During final design, additional studies should be conducted to determine the most cost-effective method. These studies would investigate removal of individual VOCs at low concentrations.

The carbon system would consist of fixed-bed adsorption units that would require regular on-site desorption and periodic off-site carbon reactivation. Based on the low VOC concentration, carbon reactivation would be required approximately every year. The desorption cycle would be required every 2 to 4 days.

## 6.3 FACILITIES RECOMMENDED FOR CONTROLLING EMISSIONS

Facilities at Deer Island that will require odor and VOC control systems include the following:

- o Winthrop Terminal Headworks
- o Centrifugal Grit Chambers
- o Grit Handling Building
- o Primary Wastewater Treatment (splitter, influent channels and primary clarifiers)
- o Screening Building Secondary Wastewater Treatment (splitter, selectors, aeration tanks, and influent channels for secondary clarifiers)

Preliminary sizing for these facilities was based on a ventilation rate of 12 air changes per hour for occupied spaces and three air changes per hour for unoccupied spaces. Occupied spaces include the Winthrop Terminal and the Grit Handling and Screening buildings. Unoccupied spaces include the primary clarifiers, influent channels, splitters, and secondary selector tanks.

Exhaust air volumes from the grit chambers and secondary aeration tanks were based on the actual air volume (pure oxygen for aeration tanks) introduced to the process.

In addition to normal ventilation, a maintenance ventilation volume was included for the primary clarifiers. The maintenance system allows for two clarifier basins to be out of service. During this time, these basins would be vented at 12 air changes per hour.

Table 6.3-1 lists the estimated exhaust air volumes for the Deer Island wastewater treatment facility and the Nut Island headworks. Because of the large distances between treatment facilities at Deer Island, six odor/VOC control facilities would be required. The table identifies the control facilities and lists the wastewater treatment facilities they will serve.

Based on typical values from other wastewater treatment plants, the average hydrogen sulfide emission rate from all wastewater processes was estimated to be 15 ppmv. The selected control system, scrubbing followed by carbon adsorption, would remove 95 to 99 percent of the hydrogen sulfide from the air stream. We used 95 percent on emission calculations.

The majority of the VOCs would be removed by carbon adsorption. The activated carbon would be capable of removing 70 to 90 percent of the VOCs from the air stream. Eighty-five percent was used on emission calculations.

After the activated carbon has become saturated with VOCs, desorption would be required. For the Deer Island treatment plant, carbon desorption would occur approximately every 4 days. The carbon beds would be thermally desorbed in place on a schedule that allows several beds to remain in service for VOC control. Once per year, the carbon would be removed, transported to an off-site facility for regeneration, then returned for use at Deer Island. Desorbed VOCs would be treated in a fume incinerator, with heat recovery systems being supplied to the thermal desorption system.

Depending on the VOC adsorbed, activated carbon is capable of removing 0.05 lb to 0.25 lb of VOC per pound of carbon. For this study, the activated carbon capacity was based on 0.15 lb VOC per pound of carbon. The overall VOC removal rate was estimated to be 85 percent. The fume incinerator will be designed to achieve 99.99 percent destruction of the desorbed VOCs.

Each odor/VOC control facility would consist of wet scrubbers followed by carbon adsorption units. The exhaust air would be drawn through the units by fans and the treated air would be discharged through a stack to the atmosphere. Data on numbers of scrubbers, adsorbers and fans are shown on Table 6.3-1. Operating data are shown on Table 6.3-2.

#### **6.4 DEMONSTRATION OF BEST AVAILABLE CONTROL TECHNOLOGY (BACT)**

The justification of BACT is influenced by the selection of wastewater-treatment processes for which a control system is proposed. In the case of Deer Island, air pollution control systems are proposed for the entire facility, up to and including the aeration tanks. For air emissions, the secondary clarifiers and the disinfection tanks will remain uncovered and uncontrolled.

To demonstrate that a selected control system represents BACT, it is necessary to evaluate its energy, economic, and environmental impacts. Impacts on energy consumption are deemed adverse when the selected system requires an exorbitant amount of energy or a source of energy not

Table 6.3-1  
DESCRIPTION OF AIR EMISSION CONTROL FACILITIES

<u>Location</u>	<u>System Capacity</u>	<u>No./Size of Packed Tower Scrubbers</u>	<u>No./Size of Dual Bed Carbon Adsorbers</u>	<u>No./Size of Exhaust Fans</u>	<u>Building Size</u>
Winthrop Terminal	15,300 scfm	(2) 6 ft diameter	(2) 12 ft diameter	(2) 15,300 scfm	50 ft x 80 ft x 28 ft height
East Air Emission Control Complex:	--	--	--	--	85 ft x 150 ft x 30 ft height
Grit Chambers	19,000 scfm	(2) 6 ft diameter	(2) 12 ft diameter	(2) 19,000 scfm	--
Grit Handling Bld.	21,000 scfm	(2) 7 ft diameter	(2) 12 ft diameter	(2) 21,000 scfm	--
Primary Clarifiers	39,800 scfm	(2) 9 ft diameter	(2) 12 ft diameter	(2) 39,800 scfm	--
Clarifier Maint.	22,100 scfm	(1) 7 ft diameter	(1) 12 ft diameter	(1) 22,100 scfm	--
West Air Emission Control Complex:	--	--	--	--	80 ft x 125 ft x 30 ft height
Grit Chambers	19,000 scfm	(2) 6 ft diameter	(2) 12 ft diameter	(2) 19,000 scfm	--
Primary Clarifiers	32,600 scfm	(2) 8 ft diameter	(2) 12 ft diameter	(2) 32,600 scfm	--
Clarifier Maint.	22,100 scfm	(1) 7 ft diameter	(1) 12 ft diameter	(1) 22,100 scfm	--
Screening Building	21,000 scfm	(2) 7 ft diameter	(2) 12 ft diameter	(2) 21,000 scfm	60 ft x 75 ft x 28 ft height
Secondary Treatment (East)	21,000 scfm	(2) 7 ft diameter	(2) 12 ft diameter	(2) 21,000 scfm	50 ft x 80 ft x 28 ft height
Secondary Treatment (West)	18,000 scfm	(2) 5 ft diameter	(2) 12 ft diameter	(2) 18,000 scfm	50 ft x 80 ft x 28 ft height
Nut Island Headworks	55,000 scfm	(3) 7 ft diameter	(4) 12 ft diameter	(4) 27,500 scfm	65 ft x 100 ft x 20 ft height



**Table 6.3-2**  
**Power and Chemical Requirements for Air Emission Control Facilities**

Location	Power (kw)	Sodium hydroxide (gpd)	Sodium hypochloride (gpd)
Winthrop Terminal	200	56	38
East Air Emission	240	84	57
West Air Emission	200	54	37
Screening Building	80	22	15
Secondary Treatment (East)	120	18	12
Secondary Treatment (West)	120	15	10
Nut Island Headworks	200	56	38



readily available within the area. Economic impacts are deemed adverse when the annualized cost of control exceeds a certain predefined amount. For the purpose of this BACT evaluation, economic control is assumed when the annual cost of control is less than or equal to \$5000 per ton of pollutant removed. Environmental impacts are deemed adverse when the ambient impacts of the released pollutants exceed critical environmental levels established for the project under review -- in this case the AALs presented in Section 3. In general, the economic and environmental aspects of an evaluation will dictate the justification of a proposed system as BACT.

Table 6.4-1 presents a summary of the emission calculations presented previously in Section 5 for the flow and load conditions representing the annual operating regime for the oxygen feed system. This table shows an uncontrolled emission rate for the PPI/HSL equal to 98.24 tons/yr. and a controlled rate equal to 14.66 tons/yr. The total VOC emission estimates are based on the range of the total VOC-to-individual constituents relationship defined earlier as 20 to 50.

As shown in Table 6.4-1, the proposed control system -- covering and control of air emissions up to the secondary clarifier -- will reduce the total VOC emissions from the treatment plant by an amount ranging between 1672 and 4180 tons/yr. Preliminary cost estimates indicate the annual cost of control is approximately \$800,000 for the primary treatment units and \$1,825,000 for the secondary treatment units. These estimates do not include the cost of the basin covers because covers are required in an oxygen/activated sludge system. The amount of VOCs controlled in each unit ranges from 1050 to 2640 tons/yr in the primary system, and 620 to 1540 tons/yr in the secondary system. These values equal to a cost effectiveness of \$300-760/ton of VOC removed in the primary system and \$1180-2960/ton of VOC removed in the secondary system. These costs are less than \$5,000/ton and can be considered to be BACT.

The uncontrolled sources remaining are the secondary clarifiers and the disinfection tank. Two potential options for control exist: additional stripping and control of volatile constituents in the aeration tank; and installation of a capture and control system.

The first option will yield little reduction in the annual controlled VOC emission rate. Table 6.4-2 shows that the controlled emissions of PPL/HSL VOCs would change only about 5 percent (15.33 tons per year vs. 14.66 tons per year) if air were used to aerate the activated sludge system. It was judged, however, that the oxygen-activated sludge system would be more reliable for wastewater treatment. Because of the small difference in emissions between the oxygen and air systems, the more-reliable system (oxygen activated sludge) should be retained.

The second option would involve collection and control of the VOCs released from the uncontrolled treatment units. The emission rate from the disinfection area is so small that collection and treatment of the emission can yield only insignificant reductions. Thus control of this source is not considered technically or economically feasible. The emissions from the secondary clarifier are essentially distributed equally between the clarifier surfaces and the effluent weirs. Even without preparing a cost estimate for the pollution control devices, the cost to capture the emission far exceeds the economic range of BACT cost effectiveness stated above. For example, the cost of basin covers averages approximately \$35/square foot. The

**Table 6.4-1**  
**Summary of Annual Emissions for the Oxygen Feed System Before and After Control,**  
**tons/yr.**

Unit	Uncontrolled Emissions			Controlled Emissions		
	Individual VOCs	TRS	Total VOC	Individual VOCs	TRS	Total VOC
Grit/Primary Clarifiers	61.25	6.85	1225-3062	8.51	0.35	170-426
Aeration Tanks	35.68	5.15	714-1786	4.84	0.26	97-242
Secondary Clarifiers	1.20	0.27	24 - 60	1.20	0.27	24- 60
Disinfection	0.11	0.02	2 - 6	0.11	0.02	2- 6
Total	98.24	12.29	1965-4914	14.66	0.90	293-734

**Table 6.4-2**  
**Distribution of Air Emissions by Treatment Unit**

**EMISSIONS OF PPL/HSL VOCs IN TONS PER YEAR**

(Based on average flows and loads, weighted by high and low groundwater)

Sum of PPL/HSL VOCs to Deer Island = 307 tons per year

	Air activated sludge		Oxygen activated sludge	
	<u>Uncontrolled</u>	<u>Controlled</u>	<u>Uncontrolled</u>	<u>Controlled</u>
Grit Chamber, weir	18.65	2.59	18.65	2.59
Primary Splitter Box	28.34	3.94	28.34	3.94
Clarifier weir	14.26	1.98	14.26	1.98
Secondary splitter box	23.04	3.20	23.04	3.20
Aeration basin	16.08	2.09	3.98	0.58
Aeration basin weir	5.11	0.62	8.69	1.06
Secondary clarifier surface	0.42	0.42	0.54	0.54
Secondary clarifier weir	0.40	0.40	0.66	0.66
Chlorine contact	0.09	0.09	0.11	0.11
SUM	106.39	15.33	98.27	14.66

surface area of the secondary clarifiers is approximately 600,000 square feet. Table 6.4-1 showed that the secondary clarifiers will emit between 24 and 60 tons VOC/yr. Complete capture and 85 percent control of this emission will yield a net reduction ranging between 21 and 52 tons VOC/yr. The cost to provide the enclosure would be roughly \$21 million. In determining the annualized cost, a capital recovery factor of 0.121 is used (based on a 15 yr recovery period and an 8.625 percent interest rate). This recovery factor yields an annualized capital cost for the enclosure equal to \$2.5 million, and a cost effectiveness factor ranging from \$48,000 to over \$100,000/ton VOC removed. These costs, even before considering the cost of the equipment, are tremendously excessive and are not representative of BACT.

#### 6.4.1 SUMMARY OF BACT SYSTEM

In summary, the selected control system, consisting of a wet scrubber for odor control followed by an activated carbon adsorber for VOC control, is representative of BACT from an economic evaluation standpoint. Implementation of this control strategy will produce a reduction in the VOC emissions from the proposed treatment system of 1672 to 4180 tons/yr as compared to an uncontrolled scenario. Further capture and control of the VOCs released from the secondary clarifiers and the disinfection tanks does not meet the economic constraints of BACT. Furthermore, this level of capture and control is not practiced anywhere. Finally, the PSD review requirements for TRS (total reduced sulfur) are not triggered due to the fact that the controlled emission rate for the reduced sulfur species is much less than the 10 tons/yr significant emission level. Upon satisfying the environmental constraints of BACT, the selected air pollution control system will be in full compliance with the provisions of BACT required by the DEQE. The environmental impact assessment of the proposed configuration is presented in Section 7.

## 7.0 AIR QUALITY MODELING AND AMBIENT IMPACT ASSESSMENT

### 7.1 INTRODUCTION

This Section presents the methodology used to conduct an ambient air quality impact assessment of the potential emissions from the proposed wastewater treatment facilities. It concludes with a discussion of the results obtained from the assessment.

An ambient air quality impact assessment is a necessary part of the preconstruction approval process for any proposed source. The potential impacts that are assessed vary from project to project and can include a comparison of expected ambient air quality impacts of a project with the National Ambient Air Quality Standards (NAAQS), a Prevention of Significant Deterioration (PSD) increment, an Allowable Ambient Level (AAL), or an odor threshold for one or many pollutants proposed for release to the atmosphere.

The procedure for ambient air quality impact assessment is based on guidance available from Federal and State air pollution control agencies. The available guidance specifies appropriate methods for estimating a source's potential ambient impact and defines the data required to ensure consistent assessment from source to source and region to region. In the case of preconstruction review, an ambient air quality impact assessment is performed using computer programs that simulate movement of air pollutants between the release point and downwind ambient air based on specific source characteristics and detailed meteorological data.

Computer programs used for conducting ambient air quality impact assessments are commonly referred to as "air dispersion models." Many different dispersion models are available and approved for use by EPA. Models for a wide variety of situations and emission characteristics allow ambient impact assessments for both particles and gases: in flat terrain, elevated terrain, or some combination of terrain features (terrain is considered elevated when the surrounding land surfaces are above the top of the proposed release point or stack); for short-term averaging times (i.e., 1-h, 3-h, 8-h, or 24-h); and for long-term averaging times (i.e., 30-day, 3-month, annual, or 5-year annual composite).

#### 7.1.1 OBJECTIVES OF THE CURRENT ASSESSMENT

The first objective of the impact assessment was to calculate the expected worst-case air-quality impact of emissions from facilities proposed at Deer Island and Nut Island. The calculated impacts were compared with the most critical allowable ambient impact measure applicable to the project. The ultimate objective was to demonstrate that the worst-case ambient air quality impacts for all pollutants expected to be released from the proposed facilities would be less than the allowable levels.

### 7.2 DERIVATION OF ALLOWABLE IMPACT LEVELS

Section 3 presented a list of the VOCs measured in wastewater in the MWRA sewers and the AAL or

odor threshold limit for each. As stated in Section 3, some of the AALs were based on annual exposure limits and were transformed to a 24-h basis using a power-law relationship that depends on time and relates the ratio of one averaging rate to another. Derivation of the power-law factor was based on procedures described in References 1 and 2.

The technique used the following power-law relationship between two averaging times (1,2):

$$X_1 = X_s (t_s / t_1)^p \quad (\text{Eq. 7-1})$$

where  $X_1$  = the concentration for the longer averaging time, mg/m<sup>3</sup>

$X_s$  = the concentration for the shorter averaging time, mg/m<sup>3</sup>

$t_s$  = the shorter averaging time, h

$t_1$  = the longer averaging time, h

$p$  = the power law exponent

Power law exponents for sources with stacks less than 30 m high are given by stability class as (2):

<u>Stability Class</u>	<u>p</u>
A	0.5
B	0.5
C	0.333
D	0.2
E	0.167
F	0.167

Because the transformation of interest is from an annual basis to a 24-h basis, Equation 7-1 takes the form:

$$X_{24} = X_{ann} / (24/8760)^p \quad (\text{Eq 7-2})$$

Application of Equation 7-2 for the current assessment required compiling information on the frequency of occurrence of each stability class and calculating the transformation factor as follows:

$$X_{24} = X_{ann} / \sum_i SC_i (24/8760)^p \quad (\text{Eq. 7-3})$$

where  $SC_i$  = fractional occurrence of stability class i

i = stability class 1 through 6 (A through F)

The tabulated fractional occurrences of each stability class were based on data from Logan Airport and were determined to be:



<u>Stability Class</u>	<u>Fraction of Occurrence</u>
A	0.000343
B	0.020786
C	0.096277
D	0.689927
E	0.147328
F	0.045340

Substitution into Equation 7-3 yields a transformation factor equal to 3.35. Thus, the 24-h concentration in the area is equivalent to the annual concentration times the transformation factor of 3.35. The two averaging time concentrations would be equivalent based on the meteorological persistence observed in the area.

### 7.3 SOURCE CONFIGURATIONS

All of the wastewater units on Deer Island up to and including the effluent weirs of the aeration tanks will be covered. The air pollutant emissions from these units will be treated in a wet scrubber/activated carbon control system prior to being released to the atmosphere through one of several stacks on the Island. Emissions from the remaining sources, i.e., the secondary clarifiers and the disinfection basins, will be released to the atmosphere without control over a large area represented by the surfaces of the treatment units. Figure 7.3-1 presents a block flow diagram which describes the relationship between the emission source and air pollution control equipment on Deer Island.

To accurately model the pollutant dispersion, the parameters of each release must be defined in terms of location, strength, height, temperature, momentum, and buoyancy. These aspects are discussed below.

#### 7.3.1 SOURCE LOCATIONS

Figure 7.3.1-1 presents a diagram of Deer Island showing the placement of the various wastewater treatment units and the locations of the air pollution control equipment referenced in Section 6 and diagrammed in Figure 7.3-1. The locations of sources were established using the Universal Transverse Mercator (UTM) coordinate system. Coordinates were established for the point sources at the point of release; for areas sources, the southwest corner coordinates were obtained after 45° rotation into a north-south orientation, as required by the dispersion model.

#### 7.3.2 EMISSION RATES

Emission rates for each pollutant were calculated using the procedures presented in Section 5 and the control efficiencies presented in Section 6. As indicated in Figure 7.3-1, the treatment plant will be divided into two halves, and the wastewater treatment units within each half will be vented to different air pollution control systems. Because the construction will

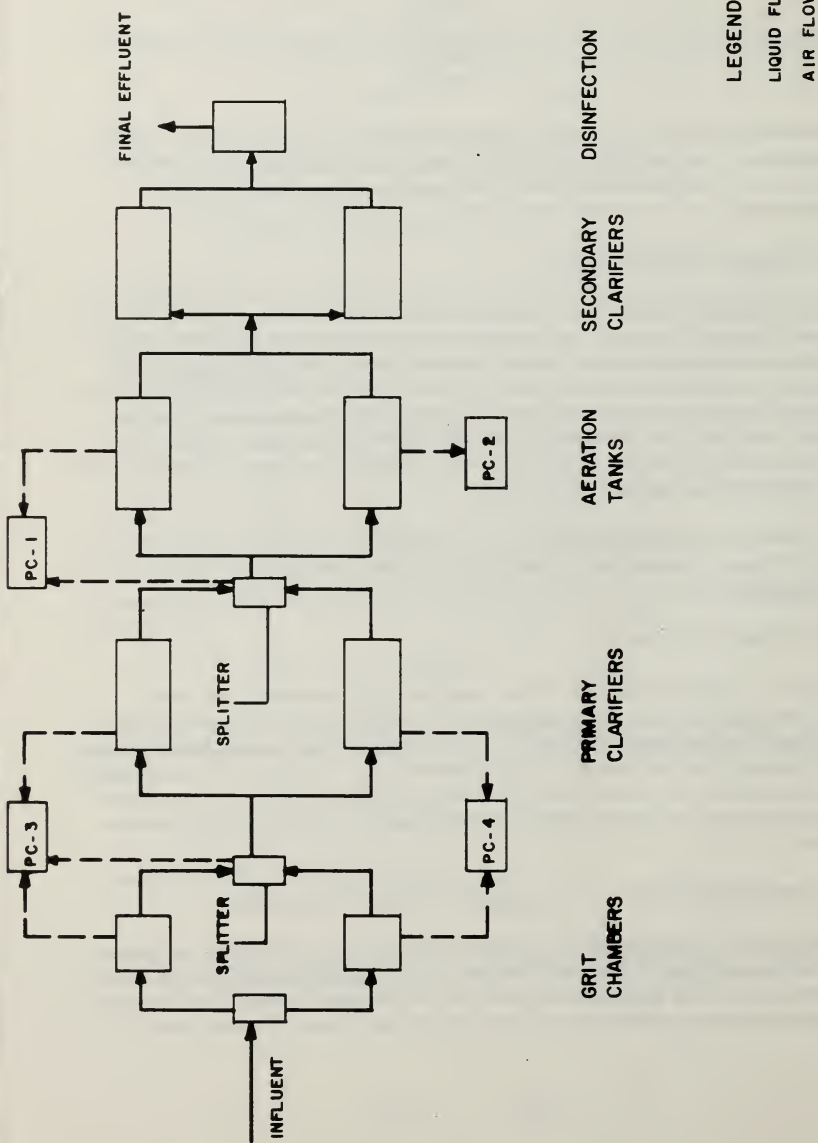


FIGURE 7.3-1  
CONTROL EQUIPMENT ORIENTATION USED FOR  
AIR QUALITY MODELING



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FIGURE 7.3.1-1  
DEER ISLAND EMISSION  
CONTROL FACILITIES LOCATIONS

entail completion of one half before beginning the second half, the first half of the plant will contain a few more sources than the second half. The calculation results presented in Section 5 provided the emission rate for each pollutant by treatment unit. The emission points are described as an allocation of the total emission by treatment unit to individual emission points is presented in Table 7.3.2-1.

### 7.3.3 EMISSION SOURCE PARAMETERS

For modeling, the Deer Island emission sources were described using six point source releases and five area-source releases. The area sources consisted of four sources describing the secondary clarifiers and one source describing the disinfection area. The point sources modeled include two points more than are actually present on the Island. These two additional points were used to represent the emission point for the primary splitter box and the aeration splitter box, and were assigned parameters identical to those of the actual stack. Thus, the model actually sees two point sources at the exact same location for PC-1 and PC-3. The model was set up in this manner to allow calculation of unit concentrations from two different sources using the same stack. Additional discussion of this item is presented in Section 7.4.1.

Stack parameters were established for the primary treatment control system stacks and the secondary treatment control system stacks at Deer Island. The stack heights were established as the Good Engineering Practice (GEP) stack height required to avoid plume downwash. The buildings in the areas of the stacks will meet the definition of "squat-type" in that the length and width will be greater than the height; thus GEP was defined as 2.5 times the height of the nearest building. In all cases, the nearest building was 30 ft (9.1 m) high.

The stacks were assumed to be identical within each treatment area even though one of the stacks in each area will handle a greater air flow. This assumption was made for practical reasons in that the plant is likely to be built symmetrically. The design stack diameter is based on an exit velocity of about 60 ft/s (18.3 m/s) at the condition of maximum flow. The actual velocity input to the model was then calculated based on the actual flow exiting the stack under normal operating conditions. All temperatures were assumed to be at ambient conditions of 68 deg F (20 deg C). Table 7.3.3-1 presents a summary of the stack parameters assigned to each controlled release point.

## 7.4 SCREENING ANALYSIS

The first step in the dispersion modeling analysis was to set up a screening model, i.e., an analysis designed to identify the constituents that had an impact of less than 50 percent of the critical ambient concentration for that constituent. A secondary purpose of the screening modeling was to provide a methodology to establish critical receptor locations. This level of assessment is consistent with the EPA Guideline on Air Quality Models (U.S.EPA, EPA-450/2-78-002R) for determining receptor grids. To assure a proper degree of conservativeness in the calculated concentrations using the screening model, several constraining assumptions were made:

**Table 7.3.2-1**  
**Fractions of Emissions Allocated to Emission Points**

Treatment Unit	Emission Point								
	PC-1	PC-2	PC-3	PC-4	AR-5	AR-6	AR-7	AR-8	AR-9
Grit Chambers	0.5	0.5							
Primary Splitter	1.0								
Primary Weir	0.5	0.5							
Aeration Splitter			1.0						
Aeration Tank			0.5	0.5					
Aeration Weir			0.5	0.5					
Secondary Clarifier					0.25	0.25	0.25	0.25	
Secondary Weir					0.25	0.25	0.25	0.25	
Disinfection Basin									1.0

**Table 7-.3.3-1**  
**Stack Parameters for the Air Pollution Control Device Stacks**

Stack	Height, m (ft)m (ft)	Diameter, m/s (ft/s)	Flue Gas Exit Velocity, K (° F)	Temperature
PC-1	22.7 (75)	1.8 (6.0)	14.3 (47)	293 (68)
PC-2	22.7 (75)	1.8 (6.0)	9.3 (30)	293 (68)
PC-3	22.7 (75)	0.73 (2.4)	18.4 (60)	293 (68)
PC-4	22.7 (75)	0.73 (2.4)	15.2 (50)	293 (68)



- o worst-case concentrations were estimated regardless of location
- o conversion factors were used to convert worst-case 1-hour concentrations to 24-hour averages
- o all meteorological conditions were considered, even when such conditions leading to the worst case estimates may not persist over a 24 hour period
- o concentrations were compared with the critical 24-hour AALs and only those falling below 50 percent of the appropriate AAL were excluded from further analysis
- o multiple source impacts were calculated as the sum of the maximum individual source impacts regardless of source location, source-receptor distances, or sensitivity to variable meteorological conditions.

#### 7.4.1 RATIONALE AND MODEL SELECTION

Two types of sources are proposed for Deer Island. These include the four point sources (stacks) and the area sources representing the secondary clarifiers and disinfection basins. Because no approved procedures exist for screening level analyses of area sources, area sources were not treated in the screening level analysis. Constituents that were expected to be released from an area source were not subjected to screening-level analysis.

The EPA-approved PTPLU Model provides a simple screening tool for determining short-term maximum impacts of point source emissions. This model is a simplified point source Gaussian model that includes variable stack and release characteristics, variable meteorological conditions over a range of wind speeds and atmospheric stability categories, optional gradual plume rise, stack-tip downwash, and buoyancy-induced dispersion. The model calculates concentrations for each set of meteorological conditions and specifies the distance to the receptor where the maximum concentration occurs.

The rationale for the use of the PTPLU Model stems from its ability to quickly model many stack configurations using a large number of meteorological conditions. This allows consideration of dispersion of individual sources under a variety of different conditions and estimation of the 1-hour concentrations associated with each condition. The 1-hour concentration estimates were subsequently adjusted to a 24-hour averaging period for comparison with the allowable ambient impact levels.

#### 7.4.2 SCREENING MODEL INPUTS AND RESULTS

Application of the PTPLU Model was consistent with general modeling practice, i.e., each point source was input to the model with its given stack parameters and the appropriate control options selected. Because of limitations in the treatment of area sources, only pollutants estimated to be released entirely from a point source were considered in the screening analysis. The results of the PTPLU analysis were reviewed to determine the maximum

concentrations for meteorological conditions consistent with a 24-hour average. For example, a neutral stability condition was thought to be reasonable for consideration, while the occurrence of the maximum concentration with a strongly unstable condition was not thought to be a reasonable condition that would occur over a 24-hour period. To be conservative, the maximum one-hour concentration was selected regardless of meteorological conditions.

Four separate emissions sources were modeled corresponding to the four stacks that will be located on the Deer Island site. The rural option of the model was selected to be consistent with land use surrounding Deer Island.

Other options were chosen to be consistent with modeling requirements and guidelines as well as to match the detailed modeling assessment described in Section 7.5. Meteorological inputs used default values of the PTPLU Model, which provides a range of wind speeds that were deemed applicable to each atmospheric stability class. For example, wind speeds ranging from 0.5 to 20.0 m/s at ground level were applied (before adjustment via extrapolation to stack height). Receptors were assumed to be located at ground level. Source parameters were those presented in Table 7.3.3-1. A unit emission rate of 1.0 g/s was used throughout the screening analysis to allow the concentration estimates to be normalized and applied to all pollutants of concern.

As stated earlier, pollutants were not screened if a portion of the emissions were from one of the uncontrolled area sources. Constituents released from both point and area sources were evaluated only in the detailed modeling assessment as described in Section 7.5. Based on the results presented in Section 5, virtually one hundred percent of the potential emissions of the following pollutants are from point sources:

- o benzene
- o ethylbenzene
- o methylene chloride
- o tetrachloroethene
- o toluene
- o trans-dichloroethene (1,2)
- o trichloroethene
- o trichlorofluoromethane
- o acetone
- o 2-butanone
- o total xylenes
- o naphthalene
- o chlorobenzene
- o benzyl alcohol

The maximum 1-h concentrations derived from the PTPLU analysis are presented for each of the four stacks in Table 7.4.2-1. For each point source, two concentration estimates are presented. The first concentration represents the maximum 1-h value derived from the PTPLU output. The second concentration represents the 24-h adjusted concentrations. For this analysis an adjustment factor of 0.4 as recommended by EPA was used to convert from a 1-h to a

**Table 7.4.2-1**  
**Unit Results of PTPLU Screening Analysis of Point Sources**

Source	NormalizedMaximum 1-h Concentration, $\mu\text{g}/\text{m}^3$	NormalizedMaximum 24-h Concentration, $\mu\text{g}/\text{m}^3$	Distance to Maximum, m
PC-1	20.28	8.11	256
PC-2	31.39	12.56	265
PC-3	39.19	15.68	287
PC-4	47.78	19.11	263

24-h concentration. (EPA-450/4-77-001, October 1977).

Review of the results in Table 7.4.2-1 indicates that the maximum impacts will typically occur within about 300 m of the individual sources. Because the shorelines are within this distance, the maximum impacts might occur there. Further review of the PTPLU results for other wind speed/stability class combinations indicates that maximum concentrations could be expected to occur at downwind distances of 500 m or less for all meteorological conditions. These results formed the basis for selection of appropriate downwind distances in the detailed analysis described in Section 7.5.

Using the results presented in Table 7.4.2-1 along with the pollutant specific emissions for a maximum load/minimum flow scenario resulted in the 24-hour pollutant-specific concentration estimates stated in Table 7.4.2-2.

The concentrations of the individual four point sources were added together, disregarding the location of the maximum impact or the meteorological conditions under which they occurred. This methodology was thought to provide a factor of safety and to assure that any chemical constituents screened would not have an adverse ambient air impact. Of the 14 chemicals under consideration in the screening analysis, 12 could have been dropped from further detailed consideration. The maximum 24-hour concentrations of the 12 chemicals were less than 50 percent of the applicable ambient impact level. The 50 percent criterion was selected on the basis of the typical factor two assigned to the accuracy of dispersion models. The chemical constituents that did not pass this screening test were included in the detailed analysis. As a final check on the screening results, the 12 chemicals that passed the analysis were maintained in the initial detailed modeling for comparison to the PTPLU concentration estimates (adjusted for 24-hour averaging).

## 7.5 DETAILED MODELING ANALYSIS

The dispersion modeling methodology used in the analysis of emissions of various chemical constituents from the proposed Deer Island secondary treatment facility was selected on the basis of the required source and modeling criteria which included:

- o large area sources emitting at ground level in addition to point sources
- o multiple gaseous emissions
- o a 24-hour averaging period that should be based on the average of hourly concentrations
- o ability to specify discrete receptor locations
- o site-specific meteorological data

The modeling analysis herein fulfills these requirements and meets the requirements of the Guideline on Air Quality Models (EPA-450/2-78-027R, July 1986). The following subsections present the model selection, input/output requirements and selection, the meteorological data selected, the receptor grid used, the derivation of chemical-specific concentration estimates for 24-h averages due to each source, and the summary of the resultant impacts analysis and comparison to the 24-h limiting concentrations.

**Table 7-4.2-2**  
**Maximum 24-h Pollutant-Specific Screening Results,  $\mu\text{g}/\text{m}^3$**

Constituent	Maximum 24-h Concentration						
	PC-1	PC-2	PC-3	PC-4	Total	AAL	1/2 AAL Omit?
Benzene	0.04	0.02	0.04	0.00	0.10	4.0	2.0 Y
Ethylbenzene	0.12	0.06	0.18	0.06	0.42	120	60 Y
Methylene chloride	0.62	0.32	0.55	0.00	1.49	8.0	4.0 Y
Tetrachloro- ethene	0.32	0.12	0.22	0.00	0.66	20.6	10.3 Y
Toluene	0.31	0.16	0.33	0.06	0.86	51.0	25.5 Y
Trans- dichloro- ethene (1,2)	0.10	0.05	0.09	0.00	0.25	110	55 Y
Trichloro- ethene	0.17	0.08	0.30	0.18	0.72	20.4	10.2 Y
Trichloro- flouro- methane	0.11	0.06	0.09	0.00	0.26	762	381 Y
Acetone	0.04	0.02	0.05	0.00	0.11	8000	4000 Y
Butanone	0.01	0.00	0.01	0.00	0.02	160	80 Y
Xylenes	0.49	0.26	0.44	0.00	1.18	59.0	29.5 Y
Napthalene	0.23	0.12	0.21	0.00	0.56	14.0	7.0 Y
Chlorobenzene	0.10	0.05	0.09	0.00	0.24	6.3	3.2 Y
Benzyl alcohol	0.01	0.00	0.01	0.00	0.02	NA	NA N

### 7.5.1 MODEL SELECTION

The dispersion model selected for detailed analysis of the 24-h ambient impacts was the short-term version of the Industrial Source Complex (ISCST) Model (EPA-450/4-86-005a, June 1986). The ISCST Model is recognized by the Guideline on Air Quality Models as a suitable model for complex sources and for fugitive emissions. In this analysis, the UNAMAP 6 version (the most recent version and currently available through NTIS or the National Computer Center in Research Triangle Park) was used for all estimates.

To accommodate the emission calculation procedure described in Section 5, the ISCST model was linked with the emission calculation programs in a separate program referred to as "AMBIENT". AMBIENT is basically a postprocessor adapted from EPA's emission/dispersion model that allows the user to input unit emission rates to ISCST for subsequent prorating for actual rates.

The AMBIENT model was used to apply the calculated emissions from the facility to the ISCST receptor grid. Each treatment unit was assigned to an ISC source group that contained the stack data and emission rates for the applicable stack. AMBIENT also allows the user to input a pollutant-specific control efficiency factor for each source. The ISCST run was made with source group emission rates as described later. Using actual meteorological data, expected impacts of the source groups were calculated for each receptor in  $\mu\text{g}/\text{m}^3$ .

### 7.5.2 CHARACTERIZATION OF SOURCES AND EMISSIONS

For the purposes of dispersion modeling, the sources presented in Section 7.3 were characterized and input to the ISCST Model. Six point and five area sources were used to characterize the Deer Island facility. This allowed a more simplified treatment of the point source analysis than modeling each component individually. It also allowed more consistent format for proration of the unit emission impacts to pollutant specific estimates. The identification of the individual sources in the ISCST analysis and the cross-reference to the Deer Island facility identification are as follows:

- o Grit-chamber weir - ISCST source Nos. 1-2
- o Primary splitter weir - ISCST source No. 3
- o Primary clarifier weir - ISCST source Nos. 1-2
- o Aeration splitter - ISCST source No. 4
- o Aeration basin - ISCST source Nos. 5-6
- o Aeration basin weir - ISCST Nos 5-6
- o Secondary clarifier surface - ISCST source Nos. 7-10
- o Secondary clarifier weir - ISCST source Nos. 7-10
- o Disinfection - ISCST source No. 11

Several groupings of the ISCST sources were implemented to facilitate the calculation of pollutant specific concentrations in the model. The ISCST model allows the consideration of various source combinations so that the individual as well as user-selected combinations of sources may be determined. The source groupings used in the Deer Island study were:



- o Source group 1: ISCST Nos. 1-2 (PC-1,2)
- o Source group 2: ISCST No. 3 (PC-1)
- o Source group 3: ISCST No. 4 (PC-3)
- o Source group 4: ISCST Nos. 5-6 (PC-3,4)
- o Source group 5: ISCST Nos. 7-10 (AR-5,8)
- o Source group 6: ISCST No. 11 (AR-9)

These source groups allowed the prororation of the normalized concentrations to those consistent with the appropriate source- emission combinations.

Because of the multitude of pollutants requiring an impact assessment, the goal was to establish a methodology that would allow calculation of unit response concentrations, i.e., the impact of 1 g/s from a point source or 1 g/s/m<sup>2</sup> from an area source. To facilitate this goal without tremendously increasing the computations required in the emission calculation phase, emissions were calculated by unit (as described in Section 5) and the ISCST model emissions inputs were specified based on the fraction of each unit's emission that was delivered to each individual stack on Deer Island (as presented previously in Table 7.3.2-1). For example, ISCST sources 1 and 2 were each input with an emission rate of 0.5 g/s, because one-half of the pollutants released from the primary treatment systems go to each of these two stacks. Source 3, however, with identical parameters as source 1, was input with an emission rate of 1 g/s because all of the pollutants released from the primary splitter go to only one stack. This allowed easy prororation when considering the pollutant-specific emissions in the ambient program.

### 7.5.3 METEOROLOGICAL DATA

Calculation of maximum 24-h concentrations in ISCST was based on the use of five years of meteorological data. These data were obtained in hourly format from the National Weather Service office at Logan Airport (Station No. 14739) for the surface parameters, and from Portland, Maine (Station No. 14764) for the mixing height data. These data were processed together into the appropriate format for the ISCST Model. The ISCST model directly accessed these files during processing.

### 7.5.4 MODEL OPTIONS

The use of the ISCST Model required that multiple input/output options be selected before the model would perform the desired calculations in the desired format. In all cases, the options were selected in concurrence with those recommended by the Guideline on Air Quality Models and with those consistent with the requirements of the analysis. Table 7.5.4-1 presents all major options used in this analysis. Individual print options (and other less important options not presented here) are given in the actual ISCST Model printouts.

**Table 7.5.4-1**  
**Options Used in the ISCST Analysis of the Proposed**  
**Deer Island Secondary Treatment Facility**

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Option Description
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Meteorological data were input using preprocessed data and Option = 1
The rural mode was used for the Deer Island site.
Wind profile exponents for P-G stability classes A-F were the following: rural applications--0.07, 0.07, 0.10, 0.15, 0.35, 0.55.
Vertical potential temperature gradients used were ISCST default values.
Buoyancy-induced dispersion was used.
Wind system measurement height was set to 10 meters.
Rectangular UTM coordinates were used for all receptor locations.
Building aerodynamic downwash calculations were not required.
Program control parameters, receptors, and source input data were output.
24-hour concentrations were calculated and output for each source group.
The calms processor was used in all modeling.

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### 7.5.5 RECEPTORS

The screening analysis performed in Section 7.4 indicated that the facility stacks have their maximum impacts at less than 300 m, and that the maximum impacts may occur at or near the shoreline. To accommodate this possibility, receptors were placed along the shoreline as well as within another 100 m or so along the shoreline in potentially critical receptor locations as determined from screening analysis. Further review of the PTPLU results for less critical wind seed/stability class combinations indicated downwind distances of 500 m or less for maximum impact for all meteorological conditions. Maximum concentrations for ground-level area source emissions occur typically near the sources. This fact, along with the screening analysis discussed in Section 7.4 for the point sources, was sufficient justification for the placement of receptors for this more detailed modeling.

Figure 7.5.5-1 presents the general layout of the selected receptor locations. The general wind persistence patterns are shown in Figure 7.5.5-2, which is a windrose for 1985 for Logan Airport. These patterns were also used as a guide to receptor placement. Given these selection tools as well as the resource and time constraints due to the number of sources requiring processing over all hours of a year, the number of receptors was limited to 68. Of these 68 receptors, five were located in surrounding communities as shown in Figure 7.5.5-3. A larger, more complex grid of receptors was not deemed necessary because the selected locations provided representative coverage of the maximum concentration locations and any estimates made at these sites were conservative.

### 7.5.6 ISCST UNIT EMISSION RESULTS

Table 7.5.6-1 presents the maximum concentration calculated for each source group included in the ISCST analysis using a unit emission rate for each of five years of meteorological data. The maximum concentrations resulted from using 1985 meteorological data for all source groups except the PC-3 and 4 source group, which had a maximum resulting from the use of 1984 data. Because the primary treatment area, which is in ISCST source groups PC-1 and PC-2, has a greater emission rate than the secondary treatment area, the 1985 meteorological data were selected to represent the year with the greatest potential for a worst-case ambient impact. This data set was then used for the detailed analysis discussed in Section 7.6

Table 7.5.6-2 presents additional detail on the 1985 24-hour concentration results. This table presents the maximum calculated 24-hour concentration for each source group and identifies the location of the receptor where the maximum had occurred. The critical days of analysis are also presented. These results as they are presented provide little insight into the pollutant-specific concentrations because no correction has been made for actual emissions on a source-by-source or pollutant-by-pollutant basis.

The results presented in Table 7.5.6-1 were used to provide detail on locations and the spatial distribution of the maximum impacts produced by the various source groups modeled. These locations are also given in Figure 7.5.6-1, which shows the critical receptors were typically

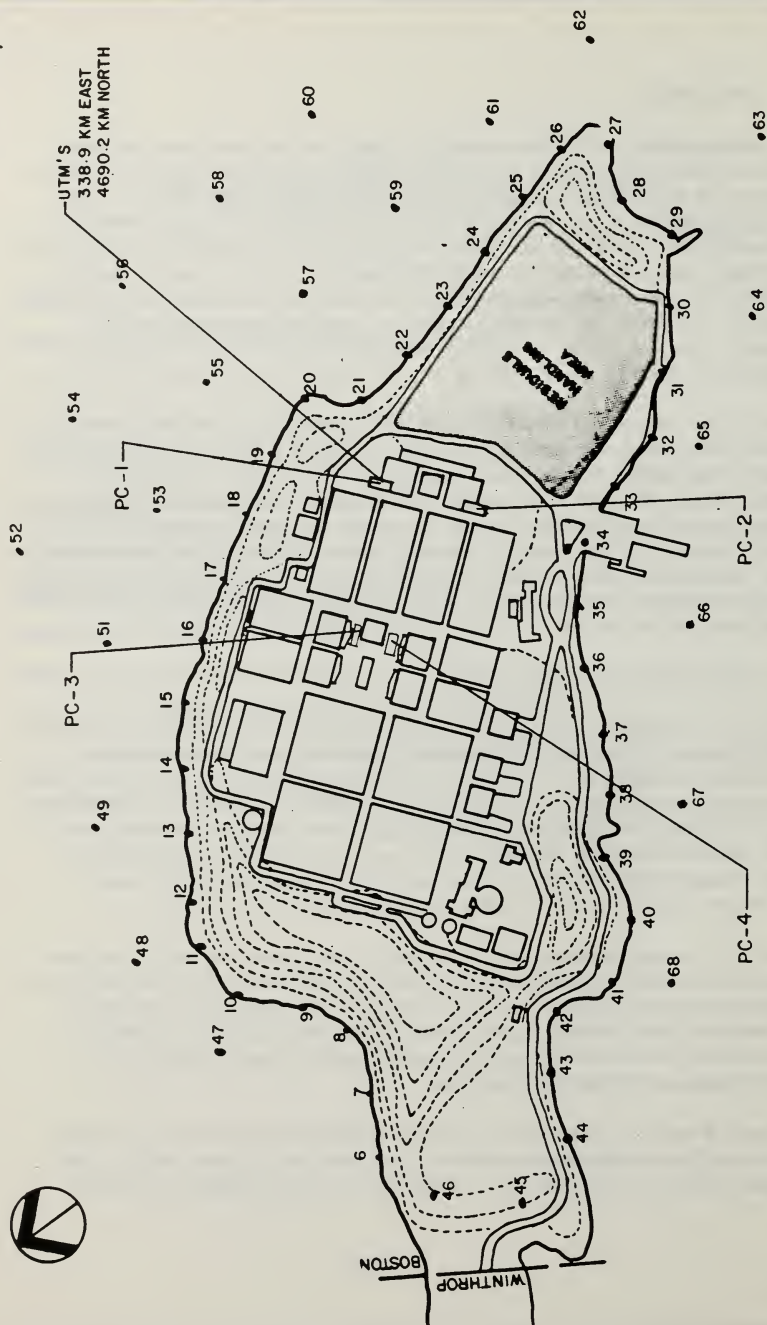
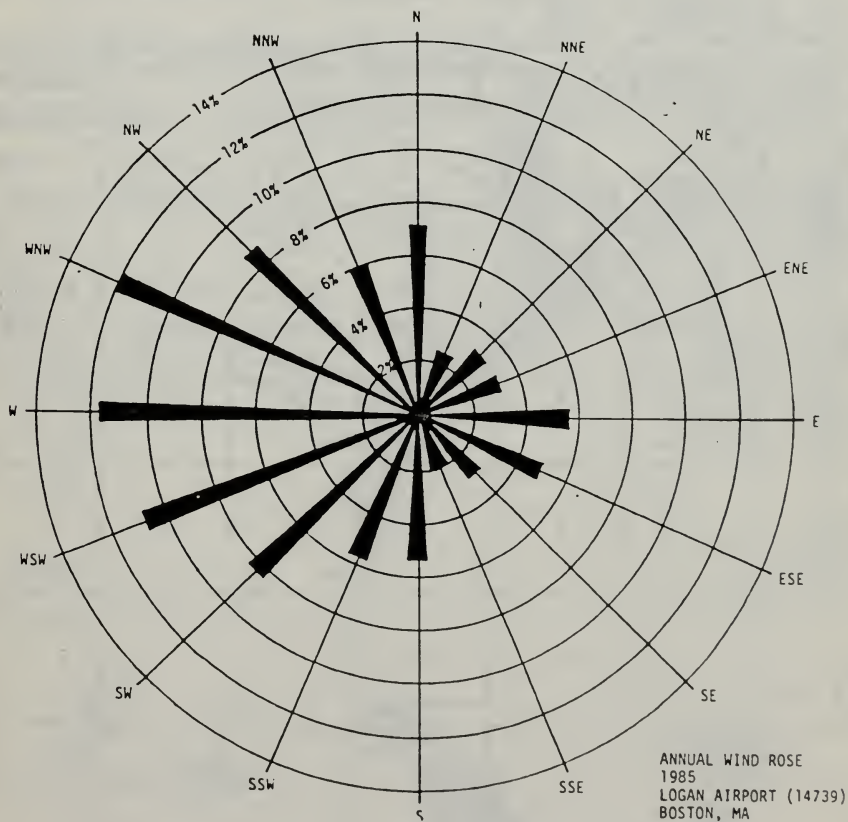


FIGURE 7.5.5-1  
EMISSION CONTROL FACILITIES  
AND RECEPTORS

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY



MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

FIGURE 7.5.5-2  
ANNUAL WIND ROSE FOR  
LOGAN INTERNATIONAL AIRPORT, 1985





**MASSACHUSETTS  
 WATER RESOURCES  
 AUTHORITY**

**FIGURE 7.5.5-3  
 ADDITIONAL RECEPTORS USED IN THE  
 DEER ISLAND ISCST DISPERSION MODELING**



**Table 7.5.6-1**  
**Maximum 24-hour normalized Concentrations For Each Year of**  
**Meteorological Data,  $\mu\text{g}/\text{m}^3$**

Source Group No.	Meteorological Year				
	1981	1982	1983	1984	1985
PC-1, 2	5.6	5.7	5.5	7.9	9.3
PC-1	6.2	6.3	5.7	6.1	8.6
PC-3	10.3	9.4	9.2	11.8	12.2
PC-3, 4	8.9	8.9	7.8	11.8	10.2
AR-5 to 8	977,978	1,237,975	1,273,632	999,077	1,227,326
AR-9	1,912,789	2,613,030	3,583,894	2,780,472	3,738,323

**Table 7.5.6-2**  
**Unit Emission Results of ISCST Analysis using 1985 Data.**

Source Group No. (ISCNO)	Description	Maximum Normalized 24-h Concentration, $\mu\text{g}/\text{m}^3$	Critical Day	Coordinates, m	
				X	Y
1 (1,2)	PC-1, PC-2	9.3	130	339,300	4,690,500
2 (3)	PC-1	8.6	130	339,300	4,690,500
3 (4)	PC-3	12.2	37	338,800	4,689,690
4 (5,6)	PC-3, PC-4	10.2	223	339,200	4,690,700
5 (7-10)	clarifiers	1,227,326	295	338,780	4,690,730
6 (11)	disinfection	3,738,323	295	338,850	4,690,660

located at or near the shoreline of Deer Island. Because of the spatial distribution of sources over the property, the maximum impacts from individual sources were not expected to occur at colocated receptors. This is in fact the case as can be seen in the figure. The maximum concentrations due to the secondary clarifiers (AR-5 to 8) occurred at a nearby shoreline receptor (No. 14) to the northeast of the facility, as did that of the disinfection basin (AR-9) just southeast of the secondary clarifier impact point (No. 15). The maximum combined impact of the primary treatment system (PC-1 and 2) occurred about 300 m east of stack PC-1 (No. 54). The maximum concentrations due to the combined impacts of PC-3 and PC-4 occurred at a receptor northeast of the facility (No. 52), within about 300 m of the shoreline. Because the majority of the emissions from the proposed facility originate from the point sources (PC-1 to PC-4), the maximum combined impact of all Deer Island sources was expected to occur within 200 m or so around the eastern shoreline of Deer Island.

As a check on the critical receptor locations and days found in the ISCST Model analysis, a grid of receptors at 100 m intervals was placed around each critical receptor. For each critical day noted in Table 7.5.6-2, a separate ISCST Model analysis was performed to ascertain if the previously determined critical receptor was in fact located at the point of maximum expected impact. The detailed grid in Figure 7.5.6-1 provided a sufficient selection of receptor locations to render such a finding. The results of this critical day analysis showed that the critical receptor locations in the original ISCST Model analysis grid (Figure 7.5.5-1) were higher than any additional receptors in the detailed grid for the critical day analysis. Thus, the original selection of receptor locations was sufficient for finding the locations of maximum impacts.

## 7.6 RESULTS OF DETAILED ANALYSES

The AMBIENT program was used to postprocess all ISCST Model results (1-hour concentrations for each source at each receptor for each hour of meteorological data) obtained using the 1985 meteorological data. The 1985 meteorological data were used for this analysis because they had been demonstrated to yield the highest ambient concentrations for the most important sources.

Table 7.6-1 presents a summary of the AMBIENT results on a 24-h basis along with a comparison to AALs or other critical impact level. These maximum ambient impacts are based on the emission rate produced from the minimum-flow, maximum-load scenario and represent the worst-case potential impacts from the facility on a short-term basis. The maximum unit emission concentrations from the ISCST Model analysis were used disregarding the fact that the temporal concurrence of worst-case emissions and dispersion meteorology may have a very low frequency of occurrence.

The comparison of maximum calculated ambient impacts to critical ambient levels indicates that the ambient impact of constituents present in the Deer Island influent and released from the treatment system will be much less than the critical levels even at the shoreline of Deer Island.

Figure 7.5.6-1 presents the locations of the maximum ambient impacts as determined by the

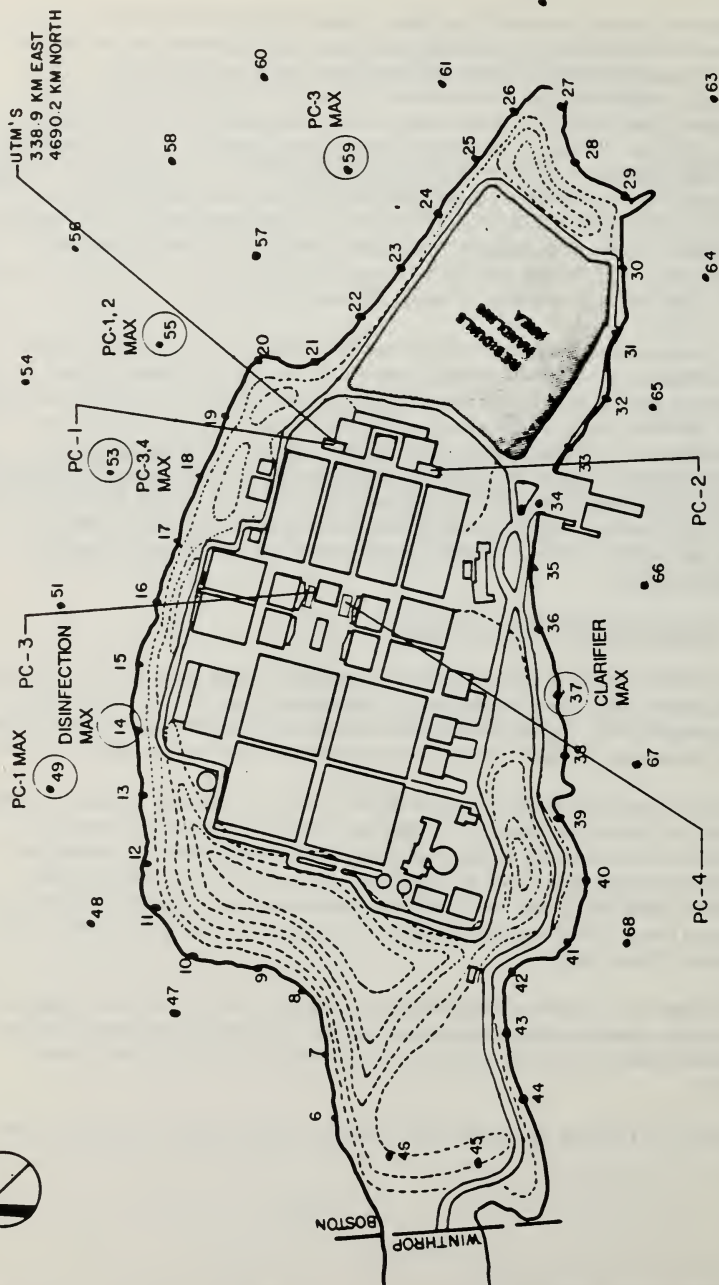


FIGURE 7.5.6-1  
LOCATIONS OF IMPACTS FOR  
DEER ISLAND EMISSION SOURCES

**Table 7.6-1**  
**Comparison of Critical and Calculated 24-hour Concentrations for**  
**Constituents Released From the Proposed Deer Island Treatment**  
**Facility,  $\mu\text{g}/\text{m}^3$**

Constituent	Odor Threshold	Allowable Ambient Level	Worst-case 24-hour Concentration
Acetone	240000	8000	0.08
Benzene	15000	4.0	0.07
Benzyl alcohol	24700	NA <sup>1</sup>	0.01
Bromomethane	NA	2.6	0.53
2-Butanone (MEK)	29900	160	0.02
2-Butanone, 3-methoxy, 3-methyl	NA	NA	0.10
Carbon disulfide	663	200	0.24
Chlorobenzene	980	6.3	0.18
Chloroform	10 <sup>6</sup>	1.44	0.24
o-Cresol	1170	100	<0.01
p-Creso	2.02	12.0	<0.01
1,2-Dichlorobenzene	24400	82.0	0.73
Dimethyl disulfide	5.0	NA	<0.01
Dimethyl sulfide	2.57	NA	0.01
Ethyl benzene	615000	120	0.22
Ethyl ether	2550	160	0.33
Hexone (MIBK)	1950	280	0.40
Methyl mercaptan	4.19	NA	0.16
Methylene chloride	88000	8.0	1.1
Naphthalene	NA	14.0	0.41
N-Nitrosodiphenylamine	NA	NA	<0.01
Pentane, 2-meth, 2,4,4-trimethyl	NA	NA	0.17
Phenol	195	52.0	<0.01
2-Propanone, 1-flouro	NA	NA	0.03
Styrene	639	39.0	0.30
1,1,2,2-Tetrachloroethane	3480	1.2	0.49
Tetrachloroethene	34400	20.6	0.43
Toluene	649	51.0	0.55
Trans-1,2-dichloroethylene	341	110	0.18
1,1,1-Trichloroethane	553000	1300	0.52
Trichloroethene	272000	20.4	0.33
Trichlorofluoromethane	NA	762	0.20
Xylene	220	59.0	0.88

<sup>1</sup> No data available.

AMBIENT program. The figure can be used to illustrate the source/emission combinations of most importance to the detailed analysis. For example, 18 compounds produced maximum impacts at receptor No. 52 which, as shown previously in Figure 7.5.6-1, is also the maximum receptor for PC-1 and PC-2 impacts. The effect is that a large fraction of these compounds are released from the primary treatment system (see also Figure 7.3-1. Review of the emission results presented in Section 5 and summarized in Table 6.4-1 shows that many of the compounds are released in greater amounts from the primary treatment area than any other area of the plant. Similarly, receptor Nos. 13 and 14 were the locations of calculated maximums for 9 and 3 compounds, respectively. These receptors are very near the ISCST maximum receptor locations for AR-5 through AR-8 (secondary classifiers) and AR-9 (disinfection). As shown previously in Table 5.6-2, 12 individual compounds are emitted from these two treatment areas.

To determine if the odor threshold for methyl mercaptan was exceeded, the 15-minute maximum concentration was selected from the AMBIENT Program for analysis. These 15-minute averages were derived in the AMBIENT Program from the 1-hour concentrations using an adjustment similar to that described in Section 7.2, except that the hourly specific exponential power (related to the atmospheric stability loss) was used in the calculation. For methyl mercaptan, the maximum 15-minute average concentration was estimated to be  $0.99 \mu\text{g}/\text{m}^3$ . The odor threshold for methyl mercaptan was reported in Table 3-1 as  $4.19 \mu\text{g}/\text{m}^3$ . All other locations off-site were estimated to have concentrations lower than the maximum value of  $0.99 \mu\text{g}/\text{m}^3$ , thus, assuring that no odor problems near the Deer Island facility should persist.

The conclusion of this ambient air quality impact assessment is that the proposed secondary treatment facility for Deer Island will have inconsequential impacts on the local population in terms of ambient air quality impacts. Proposed treatment system covers, controls, and processes will be operated in such a manner that even under a worst-case scenario, the impacts will be within allowable air quality limitations at all locations acceptable to the population. At the more-easily accessible locations (neighborhood sites surrounding the facility), the impacts were found to be insignificant. The ambient air impacts will be even less at the shoreline receptors under the more routine flow and load regimes expected at the Deer Island treatment facility.



## Appendix F

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**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix F  
Geotechnical**

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## APPENDIX F

### TECHNICAL MEMORANDUM OF ONSHORE GEOTECHNICAL INVESTIGATIONS AND GEOTECHNICAL DESIGN CRITERIA (DEER ISLAND AND NUT ISLAND)

#### 1.0 INTRODUCTION

The purpose of this technical memorandum is to assess the geotechnical considerations regarding the construction of waste treatment facilities on Deer Island and Nut Island. Included is an inventory of previous studies conducted throughout the two islands, documentation of the Facilities Plan subsurface investigations, the results of the laboratory tests that characterize soil and rock properties from samples obtained during this recent investigation, and the geotechnical design criteria for the Facilities Plan. The report also includes a discussion of the general geology of Boston Harbor Islands, a listing of reference documents, and the boring logs from the Facilities Plan studies.

#### 1.1 GENERAL GEOLOGY OF BOSTON HARBOR ISLANDS

The geology of the Boston Basin is treated extensively by LaForge (1932) and most recently by Billings (1976). The surficial geology of Deer Island and Nut Island comprises mostly Pleistocene sediments of glacial origin of varying thickness. The most prominent glacial features are the drumlins which consist of a till having a generally cohesive clayey/silt matrix containing granular pieces ranging from sand to boulder size. Cobbles, pebbles, and occasional boulders, along with sandy or gravelly layers, are often interbedded with the more homogenous materials. Some till directly overlies bedrock, while in other cases the till is underlain by older glacial sediments. In still others cases the till is submerged and buried or surrounded by later marine clays. Marine coastal forces have eroded, remolded, and redeposited these glacial sediments throughout the harbor area.

The bedrock geology of the islands consists primarily of slightly metamorphosed argillite, locally known as the Cambridge Formation. The argillite is most commonly observed to be very thinly bedded or laminated to occasionally nonbedded, very fine grained (generally silt to clay size), well indurated, and medium-hard to hard.

#### 1.2 PREVIOUS INVESTIGATIONS AND INFORMATION

##### 1.2.1 DEER ISLAND

In mid-1987 a series of 10 borings was performed in the southwest portion of Deer Island in order to support the marine facilities foundation design being done by C.E. Maguire Group. Another recent geotechnical study involved the installation of groundwater observation wells.

This work which included installation of four wells in the area immediately south of the central drumlin feature, was completed in 1986 by Camp Dresser & McKee. In 1981, Metcalf & Eddy, Inc. conducted extensive geotechnical investigations on Deer Island as part of the Nut Island Facilities Planning Project, Site Options Study (1983). Included in the subsurface investigations for this study were 7 borings (3 of which were established as groundwater observation wells) and 2 seismic refraction lines totalling 1,200 linear ft.

Earlier investigations on Deer Island date back as far as 1940. Several of these Metropolitan District Commission (MDC) contracts provide extensive subsurface boring data in the area of the existing plant and to the south of the central drumlin.

Figure F-1 illustrates the locations of numerous previous borings from the investigations described above.

### 1.2.2 NUT ISLAND

In 1986 C.E. Maguire completed 1 on-island boring and 4 near-shore borings as part of the planning and design effort for the marine facilities plan (1987). A 1981 Metcalf and Eddy field study included 1 on-island boring and 11 near-shore (tidal shallow) borings (1983). In 1980 Stone & Webster performed 1 boring on Nut Island as part of a geotechnical investigation for Boston Edison Edgar Power Station in Weymouth (1980). In addition, several MDC contracts dating from the 1940s provide subsurface boring data. The locations of several of these previous borings are shown on Figure F-2.

### 1.2.3 REFERENCE INFORMATION

Further information regarding bedrock is provided by various authors in describing MDC tunnelling projects in and around the Boston Harbor vicinity. Of particular interest are papers by Billings (1975) and Rahm (1962) which provide treatises on the geology of the North Metropolitan Relief Tunnel and the Main Drainage Tunnel, respectively. Both of the tunnels terminate at the existing Deer Island treatment facility. A listing of references annotated herein and additional noteworthy references are included in this Technical Memorandum.

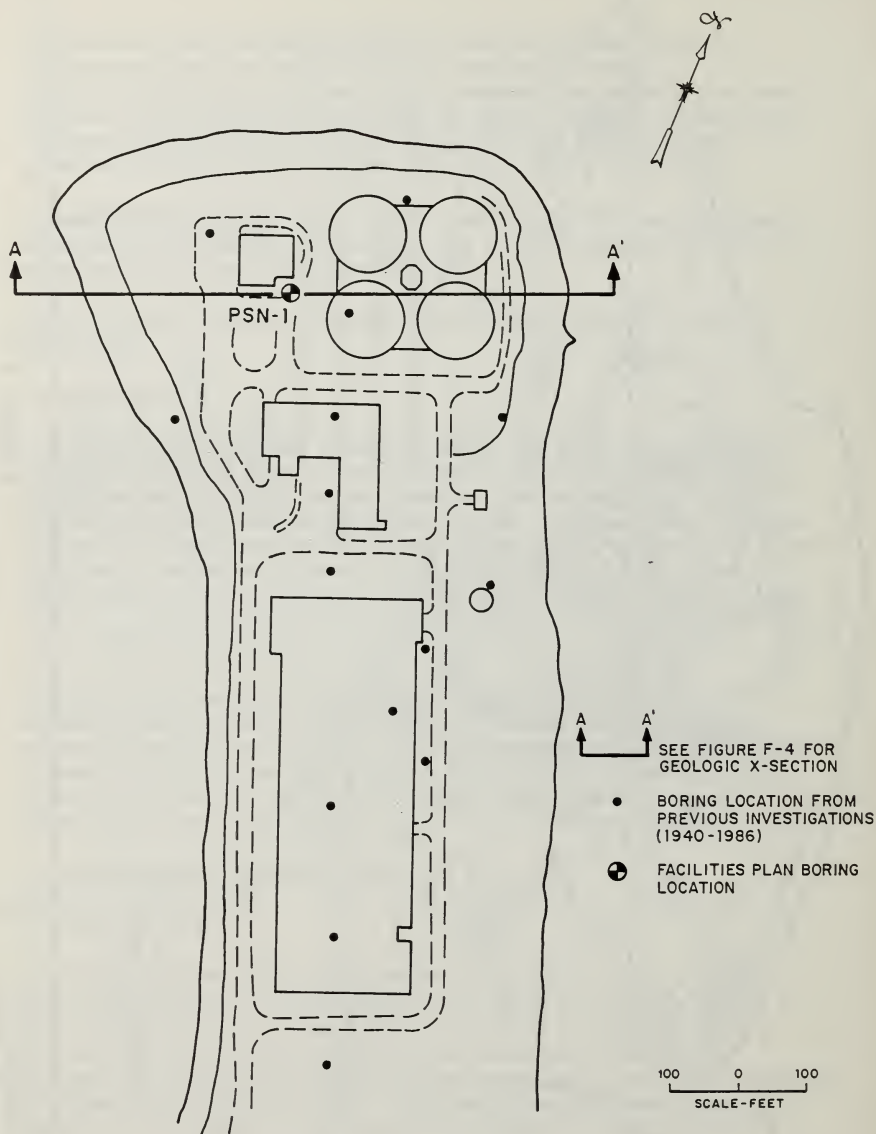
## 1.3 FACILITIES PLAN FIELD EXPLORATIONS

### 1.3.1 DEER ISLAND

The Facilities Plan subsurface investigation consisted of 8 test borings and 4 test pits. Two borings were performed on Deer Island to define the soil profile and to determine the depth to bedrock and define the type of bedrock in the general vicinity of the proposed termination of the South System tunnel and the effluent outfall inlet shaft locations. These test borings were performed with a truck-mounted drill rig by New England Boring Contractors of Connecticut, Inc. between April 20 and April 24, 1987. The drilling was supervised and all samples were logged by SWEC personnel. At each boring, split spoon samples were taken at 5-ft depth







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FIGURE F-2  
BORING LOCATION PLAN-NUT ISLAND

intervals for the initial 20 ft and then at 10 ft intervals to the top of bedrock. Approximately 10 ft of rock core was obtained at each location. Logs of these borings are attached to this Technical Memorandum. Figure F-1 illustrates the locations of the borings.

During the same period of time, 4 test pits up to 10 ft deep were excavated along the eastern flanks of the central drumlin. (Refer to Figure F-1 for test pit locations.) Test pit samples were evaluated to determine the suitability of the drumlin soils as fill materials and to aid in development of a soil disposal plan.

Between August 17 and 28, 1987, six additional borings were performed on Deer Island. At five of these locations, the purpose of the borings was to better define the areal extent and thickness of clay deposits known to exist to the north of the central drumlin in a portion of the area proposed for the secondary treatment facilities. One additional boring was performed near the southern end of the island in the area of the proposed grit and screenings landfill. These test borings were performed with a truck-mounted drill rig by Engineering Management Systems, Inc. of Rockland, Ma. The drilling was supervised and all samples were logged by SWEC personnel. Split spoon samples were taken at 2.5-ft to 5-ft intervals and 4 undisturbed samples of the clay soils were also recovered. Logs of these six borings are attached to this Technical Memorandum. Boring locations are shown on Figure F-1.

### 1.3.2 NUT ISLAND

One boring was performed on Nut Island on April 16-17, 1987, in the general vicinity of the proposed South System tunnel shaft inlet. This work was done in conjunction with, and in similar manner to, the two shaft location borings performed on Deer Island. A log of the boring is attached to this Technical Memorandum and the boring location is shown on Figure F-2.

### 1.4 LABORATORY TESTING (DEER ISLAND AND NUT ISLAND)

Testing of soil and rock samples was performed by the SWEC geotechnical laboratory. Gradation analyses were conducted on the Deer Island drumlin soils obtained from 4 test pits. All test results were quite similar, indicating fairly well graded materials with an average distribution of 35 percent gravel, 50 percent sand and 15 percent fines. Constant head permeability testing on compacted specimens from two test pits yielded results of  $10^{-7}$  cm/sec.

The results of the laboratory testing on the Deer Island clay samples are presented in Table F-1. In summary, the consolidation tests on samples of the clay yielded an average preconsolidation pressure of 7.5 ksf and an average compression index of 0.4. The unconsolidated undrained compressive strength of the clay was on the order of 1-1.5 ksf.

The results of compression tests performed on selected samples of argillite rock core from Deer Island and Nut Island are as follows:

TABLE F-1

## SUMMARY OF SOIL TESTS

## INCREMENTAL CONSOLIDATION TEST

Boring No	Sample	Depth (ft)	Approx MDC Elev. (ft)	Specimen Diameter (in)	Specimen Height (in)	Initial Water cont. (%)	Dry Unit Weight (PCF)	Initial Void Ratio	Max. Past Press. (KSF)	Compression Index
SF1	11	46	86	2.5	0.75	39.6	84.5	1.00	8.5	0.37
SF3	14	66	73	2.5	0.75	42.7	83.3	1.02	6.5	0.41
										RECOMPRESSION INDEX
								OVERCONSOLIDATION RATIO		
								2.2	0.06	
								1.2	0.07	

## UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Boring No	Sample	Depth (ft)	Approx MDC Elev. (ft)	Specimen Diameter (in)	Specimen Height (in)	Water Content (%)	Rate of Strain (% Min)	Confining Pressure (KSF)	Axial Stress (KSF)	Axial Strain (%)
SF1	11	46	86	1.40	3.50	38.7	0.4	3.6	1.52	3.5
SF3	14	66	73	1.40	3.47	41.8	0.4	3.6	1.04	4

<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Axial Compressive Strength (psi)</u>
PSD1 (Deer Island)	95.1	16,130
PSD2 (Deer Island)	121.4	9,730
PSN1 (Nut Island)	104.0	17,820

These results may be compared with similar testing performed earlier for the marine portion of this investigation (avg 11,000 psi, SWEC, 1987) and from testing by others (avg 15,000-19,000 psi, Metcalf and Eddy, 1983; SWEC, 1980).

## 1.5 DISCUSSION OF RESULTS

### 1.5.1 DEER ISLAND

The dominant topographic and geologic feature on Deer Island is the central drumlin. Another smaller, partially eroded drumlin is located at the north shore of the island and the remnant of a third drumlin is barely perceptible at the southernmost tip. The till comprising the drumlins is generally a dense to very dense mixture of clay, silt, sand, gravel, and boulders and approaches a maximum thickness of 200 ft at the central drumlin. The proportion of coarse to fine grained material is typically highly variable and irregularly distributed throughout the drumlins.

Flanking the slopes and between the drumlins are deposits of marine clays that are often overlain by glacial drift or outwash. The marine deposits consist of a gray silty clay (glacial rock flow) that typically is moderately plastic and ranges in consistency from soft to stiff. These clays vary in thickness up to 50 ft. The zone of greatest clay thickness is located approximately 500 ft north of the central drumlin traversing the site in an east-west direction. The width of this clay zone is several hundred feet with the greatest thickness along a line passing through the existing digesters and extending eastward toward the shoreline beyond the northeastern corner of the existing sedimentation basins. Other zones of extensive clay thickness are south and west of the central drumlin where up to 30 ft of clay has been observed. Sand and gravel outwash up to 20 ft thick often overlies the clays.

Organic silts, peat, and muck have been observed in low-lying areas between the drumlins in areas that generally coincide with the distribution of marine clay deposits where groundwater drainage would have been limited. From previous borings on Deer Island the peat deposits are most evident in the vicinity of the existing treatment facility north of the central drumlin, and vary in thickness up to 13 ft.

The presence of soil fill materials has been documented in the area of the existing treatment facility, to the east of the plant, and along roadways, near the western shore of Deer Island. Zones of grit and screenings exist across the southern one-third of the island. Excavation spoil or "tunnel muck" from previous shaft excavations has also been placed along the shoreline immediately to the west of the treatment facility.



Based on the numerous borings and the limited seismic work on Deer Island, the topographic relief of the bedrock surface varies from el +35 beneath the central drumlin to el -40 along the western shore of the island. The bedrock elevations at borings PSD-1 and PSD-2 are el +35 and el +21, respectively.

The bedrock observed in borings from this investigation is characterized as gray argillite and is generally very thinly bedded. Bedding is distinguished by alternating light and dark gray bands dipping at  $25^{\circ}$  to  $50^{\circ}$  from horizontal. Bedding plane joints or partings are very evident. The condition of the rock observed was generally fresh to slightly weathered with the engineering rock quality designated as "good" for the upper 10 feet.

Figure F-3 is a generalized north-south cross-section of the Deer Island geology. Based on interpretations from the results of the field studies, the extents and thicknesses of the various geologic units discussed above are presented in approximate form.

No surficial streams, swamps, or ponds nor groundwater seeps or springs have been observed on Deer Island. A few groundwater observation wells were established during an earlier investigation program in the low-lying areas adjacent to the drumlins. Water levels varied between el 108 to 114 (approximately 8 to 11 ft below ground surface). At the central drumlin there appears to be a perched water table that follows the contour of the drumlin at depths varying between 10 to 30 ft below the prevailing ground surface. Storage and recharge capacities are expected to be limited due to the dense and impervious nature of the till.

#### 1.5.2 NUT ISLAND

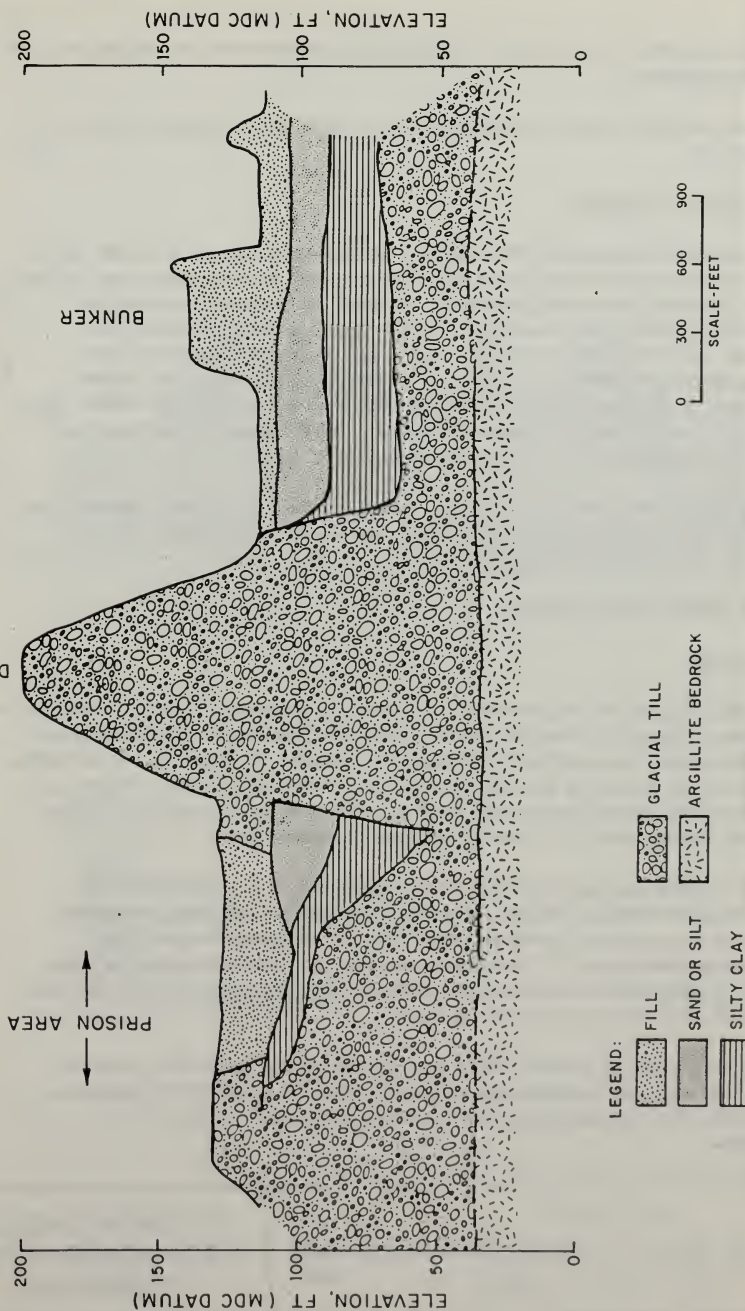
Nut Island is a partially eroded drumlin island that is connected to a larger drumlin on the mainland (Hough's Neck) by a man-made causeway. Much of the fill material used to raise the causeway for the sedimentation tanks was taken from the drumlin at the north end of the peninsula (Metcalf and Eddy, 1983).

Nut Island itself is composed primarily of till as described at Deer Island. Marine clays or organic materials are found to a limited extent in areas flanking the drumlin. Previous boreholes along the area of the causeway and in the vicinity of the existing sedimentation tanks penetrated a 2-ft-thick layer of peat overlying the marine clays and underlying fill material. The peat layer appears to be limited to the east-central portion of the peninsula (Metcalf and Eddy, 1983).

As observed in the boring from this investigation (PSN-1), taken on the remnant of the original Nut Island drumlin, approximately 95 ft of till was encountered and is generally characterized as gravelly, sandy clay. The bedrock surface at this location is at el +36.

The upper 10 ft of bedrock was sampled and is characterized as dark gray argillite, very thinly bedded at  $45^{\circ}$  from horizontal. Major fracture orientations were  $10^{\circ}$ - $15^{\circ}$ ,  $45^{\circ}$ , and nearly vertical. Many of the fractures have been rehealed by calcite and quartz. The condition of





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FIGURE F-3

DEER ISLAND GEOLOGIC CROSS SECTION A-A' (SEE FIGURE F-1)

the surficial rock may be described as fresh to slightly weathered with a poor engineering rock quality designation.

An east-west cross-section of the geology near the northern end of Nut Island is shown on Figure F-4.

## 1.6 DESIGN CRITERIA

The proposed treatment plant will be located in the north-central portion of the Deer Island covering an area 2,000 ft north-south by 1,500 ft east-west. Along the north, south and east sides and along a portion of the west side of the island, landforms will be created from on-site fill materials and/or tunnel spoils to act as visual and/or noise barriers. The effluent outfall inlet shaft will be installed in the northeast portion of the island and the South System pump station shaft is proposed for the south central island area. To the southwest of the central drumlin the bulkhead will be constructed for the pier facility. The residuals handling area will be located immediately south of the drumlin and the grit and screenings landfill will be located near the southern tip of the island.

The proposed installation on Nut Island will consist of a grit handling facility and the South System tunnel inlet shaft. These facilities will be located near the northern end of the island in the vicinity of the existing digesters.

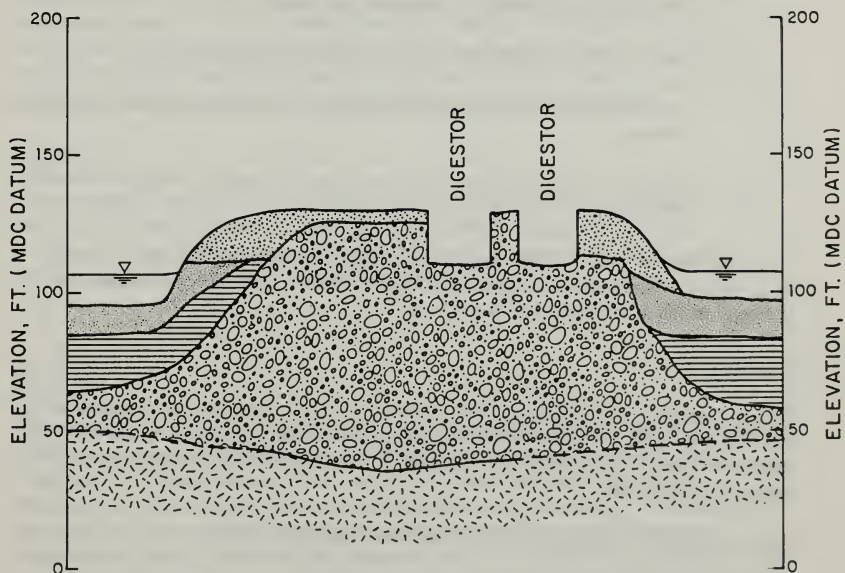
### 1.6.1 PLANT FOUNDATIONS

#### Deer Island

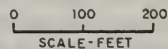
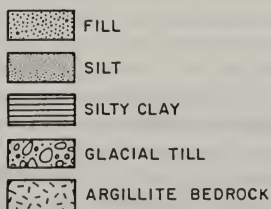
The majority of the plant foundations on Deer Island will be spread footings or mat foundations founded on glacial till. These soils have adequate bearing capacity and will not consolidate excessively under structural loads in the range of 3-5 kips/ft<sup>2</sup>. However, the working surface of the drumlin soils can be disturbed by construction activities and rainfall. Therefore, once the foundation grade has been attained it will be necessary to place a construction working surface consisting of a 9"-12" layer of sand/gravel or crushed stone.

There are portions of the proposed facility that will be founded over some existing fills, limited extents of organic material, and extensive clay deposits. Laboratory consolidation testing of the clay soils and settlement analysis based on preliminary structural load information indicate that 2"-3" of settlement may occur as a result of consolidation of the clays. Portions of both the proposed grit handling facility and secondary clarifiers are to be located in areas where clay has been encountered.

Until further field and laboratory studies more accurately define the extent and nature of these soils and a more extensive analytical program is carried out during the design phase of the project, it is recommended that pile foundations be designated for the following structures:



LEGEND:



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FIGURE F-4  
NUT ISLAND GEOLOGIC CROSS SECTION A-A'  
(SEE FIGURE F-2)

- o Grit facilities and adjacent structures (located south of the primary clarifiers).
- o The northern one-third of the secondary clarifiers.
- o Power facility (located north of the North Main Pumping Station).
- o North System force main (between existing North Pump Station and proposed grit facility).
- o Residuals handling facilities (to be determined by Residuals Management Facilities Plan)

Piles penetrating at least 10 ft into the dense glacial till can be designed for capacities of up to 120 tons. Pre-augering of the holes will aid the installation process and mitigate a portion of the noise associated with pile driving.

#### Nut Island

The grit handling facility foundations will be spread footings or mats founded on glacial till. As in the case of the Deer Island till, a stone or gravel working surface will be required to prevent disturbance of the excavated till surfaces on Nut Island due to the effects of construction equipment.

### 1.6.2 SITE DEWATERING (DEER ISLAND AND NUT ISLAND)

Dewatering of most excavations will be handled with collection of any minor seepage by open sumps. If any excavations that are in granular soils extend well below el 110 ft, a well point or deep well system may be required to control seepage into the excavation.

### 1.6.3 FILL AND BACKFILL MATERIALS

#### Deer Island

The major portion of the excavated soil material that will be available as fill to raise site grades and as common backfill is the glacial till composing the central drumlin. The till is a very heterogeneous material with significant percentages of gravel, sand, and fines. Gradation analysis on test pit samples indicate the material is a gravelly silty sand (gravel percentage ranging between 30-40 percent and silt/clay percentage from 15-30 percent). In general, these drumlin soils will be suitable as a fill to raise the site grade and for common fill providing that proper placement and compaction procedures are followed. However, the degree of difficulty in handling, placing, and compacting a widely variable graded till will be greater than that for a clean granular fill. For example, the till soils will be quite sensitive to changes in moisture content; as a result, during prolonged dry periods or rainfall, the time and effort involved in proper fill placement will be significantly increased.



There will be applications immediately adjacent to and below structures and buried pipes where a clean granular fill will be required. In these cases, a sand/gravel or crushed stone must be imported from off-site unless the inter-island or outfall tunnel spoils of argillite rock are available and determined to be suitable as backfill or bedding. Typically, the predominant particle sizes of spoils produced by tunnel boring machines are in the sand and gravel size range with maximum sizes on the order of 3-5 inches. A limited amount of crushing and/or screening may well qualify these spoils as fill suitable for certain applications.

#### Nut Island

The proposed grit handling facility and inter-island tunnel shaft will be constructed in the vicinity of the existing digesters so that there will be little or no need for fill to raise the site grade. Backfill requirements will best be met by an imported granular material, or through use of excess excavation material from Deer Island.

#### 1.6.4 LANDFORMS

##### Deer Island

The perimeter landforms will be created from excess excavation materials mainly by excavation of the glacial till from the central drumlin. Additional materials will be available from demolitions of existing structures, from excavations of sand, clay or silt for various structures, and from the South System and outfall shaft/tunnel excavations. In general, the only restrictions on the type of materials not suitable for landforms would be based on environmental criteria. Placement and compaction requirements for landform materials, while not particularly stringent, will be developed as part of the design to insure against excessive settlement, slumping, or other unstable conditions. In general, finished side slopes will be maintained at a maximum slope of 2 horizontal: 1 vertical in order to assure stability.

Within the southern landform, a secured landfill will be developed for existing Deer Island grit and screenings. The requirements of the Massachusetts Department of Environmental Quality Engineering (DEQE) will dictate the actual design including, as a minimum, a double liner and a low permeability cap layer. The soil boring performed in the area of the proposed landfill indicates that the underlying clay or till is medium-stiff to hard and as such should not undergo sufficient consolidation to endanger the integrity of the landfill liners.

##### Nut Island

Landforms are proposed for portions of the perimeter of the head of Nut Island and along the long axis of the causeway. Suitable on-site fill materials will include soils excavated for the proposed grit handling facility, tunnel shaft spoils, and demolition debris. Additional material in the form of excess drumlin excavation or tunnel spoils will be available from Deer Island as landform materials. In order to ensure stability, a 2:1 (H:V) maximum slope limitation will be maintained. If landforms are constructed over extensive zones of soft

organic or clay soils, the construction sequence may have to be carefully controlled and monitored to maintain stability of these weak soils.

#### 1.6.5 TUNNEL ACCESS SHAFTS (DEER ISLAND AND NUT ISLAND)

The vertical shafts will penetrate approximately 100 ft of post-glacial and glacial till soils. A lateral support system, such as soldier piles/lagging or casing, will be installed as the excavation progresses. While some groundwater will be likely to enter the excavation, the fine-grained nature of the greater portion of the soils will restrict the quantity of flow. For the most part, groundwater control will be accomplished by collection at sump locations.

Extension of the shaft into the argillite bedrock will be by conventional drill and blast techniques from the soil/bedrock interface to the designated tunnel depth. As in the case of the overlying soil, water seepage control will be maintained by localized sumping.

The design earth pressure coefficients and hydrostatic loadings on the shafts will be established for each shaft during the design phase of the project based on further field studies and laboratory testing.



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SITE <u>DEER ISLAND, MASSACHUSETTS</u>	J.O. NO. <u>16499.27</u>	BORING NO. <u>PSD-1</u>
COORDINATES <u>N491,620</u> <u>E747,040</u>	GROUND ELEV. (I) <u>APPROX. 116 FT</u>	SHEET <u>1</u> OF <u>3</u>
INCLINATION <u>VERTICAL</u>	BEARING _____	INSPECTOR <u>T. L. ANNARATONE</u>
DATE : START / FINISH <u>4-21-87</u> / <u>4-22-87</u> CONTRACTOR / DRILLER <u>NEW ENGLAND BORING/RAMSDELL</u>		
STATIC GROUNDWATER DEPTH / DATE <u>4.5 (FT)</u> / <u>4-22-87</u> DRILL RIG TYPE <u>MOBILE DRILL - B-61</u>		
DEPTH TO BEDROCK <u>89.5 (FT)</u> TOTAL DEPTH DRILLED <u>100 (FT)</u>		
METHODS :		
DRILLING SOIL <u>TRICOME ROLLER BIT, CASING, WATER</u>		
SAMPLING SOIL <u>SPLIT SPOON</u>		
DRILLING ROCK <u>NWD4 CORE</u>		
SPECIAL TESTING OR INSTRUMENTATION _____		
COMMENTS _____		

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	5	SS	1	4-6-5 (9")	11	SP	SAND, POORLY GRADED, MEDIUM TO COARSE, 10% GRAVEL TO 0.25IN. MAXIMUM, 5-10% NONPLASTIC FINES, BROWN GRAY
	10	SS	2	10-11-18 (16")	28	SP GP	SAND, SIMILAR TO ABOVE, EXCEPT COARSER AND ORGANIC (TOP 9") GRAVEL, 1 IN. MAXIMUM, 5-10% NONPLASTIC FINES, GRAY (BOTTOM 7")
	15	SS	3	3-3-3 (12")	6	SH	SANDY SILT, 10-15% FINE SAND, NONPLASTIC, SOME SHELL FRAGMENTS, GRAY
	20	SS	4	1-1-2-6 (14")	3	CL	SANDY CLAY, MODERATELY PLASTIC, 20-25% FINE SAND, SOFT, SOME SHELL FRAGMENTS AND ORGANIC MATERIAL PRESENT AS SAND-SIZED PARTICLES, DARK GRAY
	25						
	30						

<b>LEGEND / NOTES</b> 1. DATUM IS HDC SEWER DATUM (HDC = USCS + 105.62 FT) 2. <input checked="" type="checkbox"/> GROUND WATER LEVEL 7. SS = SPLIT SPOON 3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY. 4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION. 5. STD. PENETRATION RESISTANCE BLOWS/FT. 6. UNIFIED SOIL CLASSIFICATION SYSTEM.	<div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 10px;"> <b>BORING LOG</b> </div> <div style="text-align: center; margin-bottom: 10px;">       DEER ISLAND SECONDARY TREATMENT FACILITY     </div> <div style="text-align: center; margin-bottom: 10px;"> <b>STONE &amp; WEBSTER ENG. CORP.</b>        SKETCH No. _____     </div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;">APPROVED <i>W.E. Kelly</i></td> <td style="width: 25%;">DATE</td> <td style="width: 25%;">BORING NO. PSD-1</td> <td style="width: 25%;">SHEET 1 OF 3</td> </tr> </table>	APPROVED <i>W.E. Kelly</i>	DATE	BORING NO. PSD-1	SHEET 1 OF 3
APPROVED <i>W.E. Kelly</i>	DATE	BORING NO. PSD-1	SHEET 1 OF 3		

BORING NO. PSD-1

SHEET 2 OF 3

SITE DEER ISLAND, MASSACHUSETTS

J.O. NO.

16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
35		SS	5	7-9-10 (18")	19	CL	SANDY CLAY MODERATELY PLASTIC, 15-20% FINE SAND, STIFF, SOME GRAVEL TO 0.25 IN. MAXIMUM, GRAY WITH BROWN MOTTLING.
40		SS	6	2-2-3 (18")	5	CL	CLAY, MODERATELY PLASTIC, LESS THAN 5% SAND, FIRM, GRAY GREEN
45							
50		SS	7	2-3-3 (18")	6	CL	CLAY, MODERATELY PLASTIC, LESS THAN 5% SAND, FIRM, GRAY GREEN
55							
60		SS	8	23-23-20 (4")	43	SC	CLAYEY SAND, POORLY GRADED, MEDIUM TO COARSE, MOSTLY COARSE, SOME GRAVEL TO 0.25 IN., 10-15% SLIGHTLY PLASTIC FINES, GRAY
65							
70		SS	9	13-15-16 (9")	31	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.3 IN. MAXIMUM, 25-30% COARSE TO FINE SAND, SOME GRAVEL TO 1 IN. MAXIMUM, GRAY GREEN WITH YELLOW BROWN MOTTLING
75							
80		SS	10	19-24-31 (0)	55	-	NO RECOVERY
85							
90		SS	11	7-29-36 (18")	65	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.3 IN. MAXIMUM, 25-30% COARSE TO FINE SAND, SOME GRAVEL TO 1 IN. MAXIMUM, GRAY GREEN WITH YELLOW BROWN MOTTLING

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH No.APPROVED  
*W. E. Keller*

DATE

BORING NO.  
PSD-1SHEET  
2 OF 3

BORING NO. PSD-1


SHEET 3 OF 3

SITE

DEER ISLAND, MASSACHUSETTS

J.O. NO.

16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (3)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
TOP OF ROCK @ 89.5							
95		NX	1	98/72			<p>MED. TO DK. GRAY ARGILLITE, VERY THIN BEDDED., LAM. FAINT @ 45°-50°, FRESH TO SL. WX., MOD. HARD TO HARD, FREQUENT VEINLETS OF CALCITE (UP TO 1/16" THICK) SUBPARALLEL TO PARALLEL WITH BEDDING, JOINTING IS CLOSELY SPACED, OCCASIONAL CALCAREOUS BEDS UP TO 1/2 IN. THICK.</p> <p>90.4 FT JT @ 50° SMOOTH, FeO STAIN, PARRALLEL TO BED, CROSS JT @ 60°, SMOOTH FeO STAIN.</p> <p>90.8 FT CROSS JTS AS ABOVE EXCEPT NO FeO STAIN, SL. CALCAREOUS</p> <p>91.6 FT-92.0 FT JT. SUBVERT, SMOOTH, SL. CALCAREOUS</p> <p>91.9 FT @ 45° (PERPENDICULAR TO BED), SMOOTH, FRESH</p> <p>93.4 FT @ 50°, CALCITE FILLED</p> <p>96.8 FT JT. @ 50%, CALCITE FILLED, PARALLEL TO BED, SLIGHTLY ROUGH, IRREGULAR</p>
		NX	2	100/86			
100							END OF BORING @ 100 FT
NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.  STONE & WEBSTER ENG. CORP. SKETCH NO.           APPROVED <i>W.E. Kelly</i> DATE           BORING NO. PSD-1           SHEET 3 OF 3							





BORING NO. PSD-2

SHEET 2 OF 3

SITE

DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO.

16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RCD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	14-19-21 (18")	40	CL	SANDY CLAY, MODERATELY PLASTIC, HARD, 10-15% COARSE TO FINE SAND, MOSTLY COARSE, SOME GRAVEL TO 1 IN. MAXIMUM, LIGHT GRAY
35							
		SS	6	13-40-26 (14")	66	CL	SANDY CLAY, SIMILAR TO ABOVE, EXCEPT MORE GRAVEL, MAXIMUM SIZE 1.5 IN., LIGHT GRAY
40							
45							
		SS	7	12-13-21 (13")	34	CL	SANDY CLAY, MODERATELY PLASTIC, VERY STIFF, 15-20% GRAVEL TO 1 IN., 25-30% COARSE TO FINE SAND, GREEN GRAY
50							
55							
		SS	8	22-18-26 (14")	44	CL	SANDY CLAY, SIMILAR TO ABOVE, EXCEPT COARSER, WITH ROCK FRAGMENTS TO 1.5 IN., GREEN GRAY
60							
65							(LAYER OF COBBLES AT 68 FT)
		SS	9	10-17-22 (18")	39	SC	CLAYEY SAND, WIDELY GRADED, 15-20% GRAVEL TO 0.3 IN. MAXIMUM, COARSE TO FINE SAND, 20-25% SLIGHTLY PLASTIC FINES, GREEN GRAY
70							
75							
		SS	10	19-22-29 (15")	51	SC	CLAYEY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY COARSE, SOME GRAVEL TO 1 IN., 10-15%, SLIGHTLY PLASTIC FINES, FRESH ARGILLITE ROCK FRAGMENTS, GREEN GRAY
80							
85							
90							

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH No.APPROVED  
*W. E. [Signature]*

DATE

BORING NO.  
PSD-2SHEET  
2 OF 3



BORING NO. PSD-2

SHEET 3 OF 3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO. 16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
95		SS	11	19-18-35 (16")	53	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.3 IN. MAXIMUM, COARSE TO FINE SAND, GREEN GRAY
100		SS	12	84-42-46 (18")	88	GC	CLAYEY GRAVEL, COARSE TO FINE, MOSTLY COARSE, SUBROUNDED AND ANGULAR TO 1.5 IN. MAXIMUM ARGILLITE FRAGMENTS, 15-20% SLIGHTLY PLASTIC FINES, GREEN GRAY
105							
110							
115							TOP OF ROCK @ 115
120		NX	1	100/?			MED TO DK GRAY ARGILLITE VERY THINLY BEDDED (LAM). @ 45°-50°, FRESH, MOD HARD TO HARD, JOINTS (PARTINGS) @ 1/2 IN. TO 3 IN. SPACING, SMOOTH, MOSTLY FRESH TO CALCITE FILLED, OCCAS. CALC. VEINLET ACROSS BEDDING, OCCAS. LIGHT COLOR BEDS ARE CALCAREOUS.
125		NX	2	100/?			END OF BORING @ 126.0 FT.
130							

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH No.APPROVED  
*W. E. K...*

DATE

BORING NO.  
PSD-2SHEET  
3 OF 3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27 BORING NO. SF-1  
 COORDINATES N493.280 E746.410 GROUND ELEV. (I) APPROX. +132 SHEET 1 OF 3  
 INCLINATION VERTICAL BEARING - INSPECTOR HASAN ABEDI  
 DATE : START / FINISH 8/17/87 / 8/20/87 CONTRACTOR / DRILLER EMS/CHARLES REIL  
 STATIC GROUNDWATER DEPTH / DATE 20 (FT) / 8/21/87 DRILL RIG TYPE MOBILE B-57  
 DEPTH TO BEDROCK (FT) TOTAL DEPTH DRILLED 92 (FT)

METHODS:

DRILLING SOIL ROLLER BIT TO 90 FT., CASING DRIVEN TO 35 FT., WATER  
 SAMPLING SOIL SPLIT SPOON AT 5 FT INTERVALS TO 92 FT. SHELBY TUBE SAMPLES AT 37.5 FT and 45.0 FT.  
 DRILLING ROCK NONE

SPECIAL TESTING OR INSTRUMENTATION \_\_\_\_\_

COMMENTS \_\_\_\_\_

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
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2							FILL: SANDY GRAVEL, 20-40% BOLDERS AND COBBLES TO 24 IN. MAXIMUM, 20-40% SAND, 5-10% FINES, LIGHT BROWN.
5	SS	1	8 - 8 - 7 (11 IN.)	15			FILL: SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 1.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, BROWNISH GRAY, SOME ROOTS AND ORGANIC MATERIAL.
10	SS	2	6 - 3 - 3 (4 IN.)	6			FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% MEDIUM TO FINE SAND, STIFF, BROWNISH GRAY.
15	SS	3	2 - 3 - 4 - 4 (10 IN.)	7			FILL: SANDY SILT, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.5 IN. MAXIMUM, 10-15% COARSE TO FINE SAND, FIRM, BROWNISH GRAY.
20	SS	4	13-10-10 (10 IN.)	20	SM- ML		NOTE: LOST SAMPLE; OVERDROVE SECOND ATTEMPT TO INCREASE RECOVERY
25	SS	5	20-19-27 (13 IN.)	46	SM- ML		FILL: SANDY SILT, SAME AS ABOVE. BOTTOM 3 IN. TOP SOIL WITH MANY ROOTS.
30							(BOTTOM OF FILL AT APPROXIMATELY 17.5 FT)
							SILTY SAND, WIDELY GRADED, 5-10% GRAVEL TO 1.5 IN. MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 15-20% SLIGHTLY PLASTIC FINES, BROWNISH GRAY
							SILTY SAND, SIMILAR TO ABOVE, EXCEPT SOME DARK REDDISH BROWN INCLUSIONS

LEGEND / NOTES

- DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
- GROUND WATER LEVEL
- BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". \* INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
- % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
- STD. PENETRATION RESISTANCE BLOWS/FT.
- UNIFIED SOIL CLASSIFICATION SYSTEM.
- SS = SPLIT SPOON
- US = UNDISTURBED SAMPLE

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MIRA



STONE & WEBSTER ENG. CORP.  
SKETCH NO.

APPROVED  
*[Signature]*

DATE

BORING NO.

SHEET

SF-1

1 OF 3

BORING NO. SF-1

SHEET 2 OF 3

SITE OER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO.

15499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	6	12-14-17 (8 IN.)	31	ML SM	SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 0.3 IN. MAXIMUM, 30-40% COARSE TO FINE SAND, MOSTLY FINE, BROWNISH GRAY
							--- TOP OF CLAY AT 33 FT ---
35		SS	7	4-6-10 (16 IN.)	16	CL	SILTY CLAY, SLIGHTLY PLASTIC, STIFF TO VERY STIFF, GREENISH GRAY
		US	8		-	CL	CLAY, MODERATELY PLASTIC, GREENISH GRAY
40		SS	9	10-9-10 (18 IN.)	19	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, ONE 0.7 IN. GRAVEL PARTICLE
		SS	10	8-8-8 (18 IN.)	16	CL- CH	CLAY, MODERATELY TO HIGHLY PLASTIC, STIFF TO VERY STIFF, GREENISH GRAY
45		US	11		-	CL- CH	CLAY, SAME AS ABOVE
		SS	12	4-4-5 (18 IN.)	9	CL- CH	CLAY, MODERATELY TO HIGHLY PLASTIC, FIRM TO STIFF, GREENISH GRAY
50		SS	13	5-4-5 (18 IN.)	9	CL- CH	CLAY, SIMILAR TO ABOVE EXCEPT, ONE 0.4 IN. GRAVEL
		SS	14	5-4-5 (18 IN.)	9	CL- CH	CLAY, SIMILAR TO ABOVE EXCEPT NO GRAVEL
55		SS	15	1-2-3 (18 IN.)	5	CL- CH	CLAY, SIMILAR TO ABOVE, EXCEPT SOFT TO FIRM
		SS	16	1-2-3 (18 IN.)	5	CL- CH	CLAY, SAME AS ABOVE
60		SS	17	WOH 4-4 (18 IN.)	8	CL- CH	CLAY, SIMILAR TO ABOVE EXCEPT, FIRM TO STIFF.
		SS	18	WOR 2-3 (18 IN.)	5	CL- CH	CLAY, SIMILAR TO ABOVE EXCEPT, SOFT TO FIRM
65							
70		SS	19	6-5-6 (18 IN.)	11	CL- CH	CLAY, SAME AS ABOVE NOTE: RODS DROPPED WHILE LOWERING. SPLIT SPOON SAMPLER, N VALUE LIKELY AFFECTED
75		SS	20	WOR WOR 2-6 (24 IN.)	2	CL- CH	CLAY, SIMILAR TO ABOVE EXCEPT, VERY SOFT TO SOFT.
80		SS	21	WOR 2-19-33 (24 IN.)	21	CL- CH- SC	--- BOTTOM OF CLAY AT 81 FT --- CLAY, SAME AS ABOVE (TOP 16 IN.) CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL TO 1 IN. COARSE TO FINE, MOSTLY FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREENISH GRAY (BOTTOM 8 IN.)
85		SS	22	114-84-80	164	SM	CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL UP TO 1.5 IN., COARSE TO FINE, MOSTLY FINE SAND, SLIGHTLY PLASTIC FINES, GRAY NOTE: A PIECE OF GRAVEL LIMITED THE RECOVERY TO 2 IN. TOTAL RECOVERY.
90							

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH No.

APPROVED

DATE

BORING NO.

SHEET

SF-1  
2 OF 3

BORING NO. SF-1SHEET 3 OF 3

16499.27

SITE

DEER ISLAND SECONDARY TREATMENT FACILITY


J.O. NO.

ELEVATION (FEET) (2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)
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## SAMPLE DESCRIPTION

95	55	23	27-43-65-99 (8 IN.)	108	SM	CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL UP TO 2 IN., COARSE TO FINE, MOSTLY FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREENISH GRAY
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END OF BORING AT 92 FT

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.

 STONE & WEBSTER ENG. CORP.  
SKETCH No.

APPROVED

DATE

BORING NO.  
SF-1SHEET  
3 OF 3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27 BORING NO. SF-2

COORDINATES N493,540 E745,260 GROUND ELEV. (1) APPROX. 125 FT SHEET 1 OF 2

INCLINATION VERTICAL BEARING - INSPECTOR HASAN ABEDI

DATE : START / FINISH 8/20/87 / 8/21/87 CONTRACTOR / DRILLER EMS/CHARLES REIL

STATIC GROUNDWATER DEPTH / DATE (FT) /  DRILL RIG TYPE MOBILE B-57

DEPTH TO BEDROCK (FT) TOTAL DEPTH DRILLED 62 (FT)

METHODS :

DRILLING SOIL ROLLER BIT TO 62 FT., CASING DRIVEN TO 20 FT., WATER


SAMPLING SOIL SPLIT SPOON AT 5 FT INTERVALS TO 62 FT, SHELBY TUBE SAMPLE AT 35 FT

DRILLING ROCK NONE

SPECIAL TESTING OR INSTRUMENTATION

COMMENTS

ELEVATION (FEET)(1)&(2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
0							FILL: SANDY GRAVEL, 20-40% BOLDERS AND COBBLES TO 20 IN. MAXIMUM, 20-40% SAND, 5-10% FINES, LIGHT BROWN
2.5							
5		SS	1	7-7-8 (10 IN.)	15		FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% GRAVEL UP TO 3 IN., SOME ROOTS, 10-20% COARSE TO FINE SAND, BROWNISH GRAY
10		SS	2	4-2-2	4		FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% MEDIUM TO FINE SAND, STIFF, BROWNISH GRAY
15							NO RECOVERY
20		SS	3	15-12-10-44 (6 IN.)	22		FILL: SILTY SAND, WIDELY GRADED, 10-20% GRAVEL UP TO 1 IN. 10-20% SLIGHTLY PLASTIC, FINES, BROWNISH GRAY
25		SS	4	10-10-13 (5 IN.)	23	CL	CLAY, MODERATELY PLASTIC, 5-10% FINE SAND, VERY STIFF, BROWN
30		SS	5	6-9-10 (7 IN.)	19	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, 0.5 IN. GRAVEL PARTICLE

- LEGEND / NOTES
1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
  2.  GROUND WATER LEVEL
  3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30".  
\* INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
  4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
  5. STD. PENETRATION RESISTANCE BLOWS/FT.
  6. UNIFIED SOIL CLASSIFICATION SYSTEM.
  7. SS = SPLIT SPOON
  8. US = UNDISTURBED SAMPLE

### BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA



STONE & WEBSTER ENG. CORP.  
SKETCH No.

APPROVED

*W. E. Keller*

DATE

BORING NO.

SF-2

SHEET

1 OF 2



BORING NO. SF-2

SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO. 16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	6	4-8-9-11 (15 IN.)	17	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, 0.3 IN. GRAVEL PARTICLE
35							
	37	US	7			CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, GREENISH GRAY.
		SS	8	3-6-6 (17 IN.)	12	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT, STIFF
40							
							ENCOUNTERED PIECES OF GRAVEL AT 45 FT.
45		SS	9	9-4-4-5	8	CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, GREENISH GRAY, SEVERAL GRAVEL PARTICLES UP TO 1 IN. MAXIMUM (TOP 3 IN.)
							CLAY, MODERATELY TO HIGHLY PLASTIC, MEDIUM GREENISH GRAY.
							BOTTOM OF CLAY AT 48 FT.
50		SS	10	11-15-23-36	38		NO RECOVERY
		SS	11	11-10-9-16	19		NO RECOVERY
55		SS	12	6-6-10-26-28 (6 IN.)	36	SC-SM	CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL TO 1 IN. MAXIMUM, COARSE TO FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREEN GRAY
60		SS	13	32-59-72-80 (13 IN.)	131	SC-SM	CLAYEY SAND, WIDELY GRADED, 10-30% GRAVEL UP TO 1 IN., COARSE TO FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREENISH GRAY.
							END OF BORING AT 62 FT

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH NO.APPROVED  
*DeKell*

DATE

BORING NO.

SHEET

SF-2

2 OF 2



<b>SITE</b> DEER ISLAND SECONDARY TREATMENT FACILITY		<b>J.O. NO.</b> 16499.27		<b>BORING NO.</b> SF-3	
<b>COORDINATES</b> N493.250 E746.550		<b>GROUND ELEV. (I)</b> 139 FT		<b>SHEET</b> 1 OF 2	
<b>INCLINATION</b> VERTICAL		<b>BEARING</b>		<b>INSPECTOR</b> HASAN ABE01	
<b>DATE : START / FINISH</b> 8/24/87 / 8/25/87		<b>CONTRACTOR / DRILLER</b>		<b>EMS/CHARLES REIL</b>	
<b>STATIC GROUNDWATER DEPTH / DATE</b> (FT) /		<b>DRILL RIG TYPE</b>		<b>MOBILE B-57</b>	
<b>DEPTH TO BEDROCK</b> (FT)		<b>TOTAL DEPTH DRILLED</b>		86.5 (FT)	
<b>METHODS :</b>					
<b>DRILLING SOIL</b>		ROLLER BIT TO 86 FT., WATER CASING DRIVEN TO 40 FT			
<b>SAMPLING SOIL</b>		SPLIT SPOON AT 5 FT INTERVALS. SHELBY TUBE AT 65 FT DEPTH			
<b>DRILLING ROCK</b>					
<b>SPECIAL TESTING OR INSTRUMENTATION</b>					
<b>COMMENTS</b>					

ELEVATION (FEET)(1)(2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RDD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	1	11-BS (9 IN.)			FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% GRAVEL TO 2.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, LIGHT BROWN, SOME ROOTS. NOTE: REFUSAL @ DEPTH OF 1 FT
5		SS	2	16-22-31 (10 IN.)	53		FILL: SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 1.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, BROWNISH GRAY
10		SS	3	8-13-16-15 (8 IN.)	29		FILL: SANDY SILT, SLIGHTLY PLASTIC, WIDELY GRADED, 5-10% GRAVEL TO 0.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, BROWNISH GRAY
15		SS	4	11-6-6-13 (10 IN.)	12		FILL: SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-20% GRAVEL TO 0.5 IN. MAXIMUM, 20-30% COARSE TO FINE SAND, MOSTLY FINE, STIFF, GREENISH GRAY
20		SS	5	7-5-5-7	10		NO RECOVERY (2 ATTEMPTS)
25		SS	6	42-36-43 (8 IN.)	79	CL	— — — — — BOTTOM OF FILL AT 24 FT — — — — — SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-20% GRAVEL TO 0.5 IN. MAXIMUM 15-25% COARSE TO FINE SAND, HARD, BROWNISH GRAY INTERMIXED WITH GREENISH GRAY
30							

<b>LEGEND / NOTES</b>	1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)	<b>BORING LOG</b>	
	2. <input checked="" type="checkbox"/> GROUND WATER LEVEL	DEER ISLAND SECONDARY TREATMENT FACILITY	
	3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140LB. HAMMER FALLING 30". * INDICATES USE OF 300LB. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.	MURA	
	4. % ROCK CORE RECOVERY / ROCK QUALITY DESIGNATION.	STONE & WEBSTER ENG. CORP	
5. STD. PENETRATION RESISTANCE BLOWS/FT.		SKETCH No.	
6. UNIFIED SOIL CLASSIFICATION SYSTEM.		APPROVED	DATE
		BORING NO.	SHEET
		SF-3	1 OF 2

BORING NO. SF-3

SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO.

16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	7	19-45-7D (16 IN.)	115	CL	<u>SANDY CLAY</u> , SIMILAR TO ABOVE EXCEPT GRAVEL TO 0.3 IN.
35		SS	8	22-20-22-14 (12 IN.)	42	SM	<u>SILTY SAND</u> , WIDELY GRADED, 5-10% GRAVEL TO 0.5 IN. MAXIMUM, 5-10% FINES, BROWNISH GRAY (TOP 7 IN.)
						CL-ML	TOP OF CLAY @ 37.5 FT <u>SANDY CLAY</u> , slightly plastic, 15-30% COARSE TO FINE SAND, GREENISH GRAY (BOTTOM 5 IN.)
40		SS	9	5-10-11 (8 IN.)	21	CL	<u>CLAY</u> , MODERATELY PLASTIC, 5-10% MEDIUM TO FINE SAND, VERY STIFF, GREENISH GRAY. NOTE: A PIECE OF GRAVEL (1.5 IN.) BLOCKED THE SPOON, LIMITED THE RECOVERY TO 8 IN.
45		SS	10	1-2-2-3 (18 IN.)	4	CL	<u>CLAY</u> , MODERATELY PLASTIC, SOFT, GREENISH GRAY
50		SS	11	1-3-3-4 (20 IN.)	6	CL-CH	<u>CLAY</u> , MODERATELY TO HIGHLY PLASTIC, FIRM, GREENISH GRAY
55		SS	12	2-2-3-3 (16 IN.)	5	CL-	<u>CLAY</u> , SAME AS ABOVE
60		SS	13	WOH 3-4-4 (24 IN.)	7	CL-CH	<u>CLAY</u> , SAME AS ABOVE
65		US	14			CL-CH	<u>CLAY</u> , SAME AS ABOVE
70		SS	15	3-3-3 (18 IN.)	6	CL-	<u>CLAY</u> , SAME AS ABOVE
75		SS	16	WOH 4-3-4-6 (24 IN.)	7	CL	<u>CLAY</u> , MODERATELY PLASTIC, 5-10% FINE SAND, GREENISH GRAY, ONE PIECE OF 1 IN. GRAVEL
80		SS	17	4-4-3 (18 IN.)	7	CL	<u>SANDY CLAY</u> , SLIGHTLY TO MODERATELY PLASTIC, 10-15% GRAVEL UP TO 1 IN. MAXIMUM, 10-30% COARSE TO FINE SAND, GREENISH GRAY
82.5							BOTTOM OF CLAY AT 82.5 FT NOTE: ROLLER BITTED THROUGH 3.5 FT OF ROCK
85		SS	18	178/5 IN. REFUSAL			82.5 FT-86 FT
90							<u>GRAY ARGILLITE</u> , Wx, MOD HARD, SOME CLAY POCKETS, SL. PLASTIC, GRAY. NOTE: LOST WATER IN THE HOLE AT 86.5 FT (MAY BE BEDROCK SURFACE)
							END OF BORING @ 86.5 FT

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH NO.APPROVED  
*CEK*

DATE

BORING NO.

SF-3

SHEET

2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27 BORING NO. SF-4  
 COORDINATES N493.430 E746.320 GROUND ELEV. (I) APPROX +136 FT SHEET 1 OF 2  
 INCLINATION VERTICAL BEARING \_\_\_\_\_ INSPECTOR HASAN ABEDI  
 DATE : START / FINISH 8/25/87 / 8/26/87 CONTRACTOR / DRILLER EMS/CHARLES REIL  
 STATIC GROUNDWATER DEPTH / DATE \_\_\_\_\_ (FT) / \_\_\_\_\_ DRILL RIG TYPE MOBILE 8-57  
 DEPTH TO BEDROCK \_\_\_\_\_ (FT) TOTAL DEPTH DRILLED 67 (FT)

METHODS :

DRILLING SOIL ROLLER BIT TO 67 FT WITH WATER, CASING DRIVEN TO 30 FT.

SAMPLING SOIL SPLIT SPOON AT 5 FT INTERVALS

DRILLING ROCK \_\_\_\_\_

SPECIAL TESTING OR INSTRUMENTATION \_\_\_\_\_

COMMENTS \_\_\_\_\_

ELEVATION (FEET) (1) (2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/ROD (4)	SPT N VALUE (5) GROUP	SYMBOL (6)	SAMPLE DESCRIPTION
0							FILL: SANDY GRAVEL, BOULGERS AND COBBLES TO 24 IN. MAXIMUM, 20-40% SAND, 10-20% FINES, LIGHT BROWN
5							FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-30% GRAVEL TO 1.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, MOIST, BROWNISH GRAY
10	SS	1	3-3-2-10 (12 IN.)	5			FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% GRAVEL TO 0.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, FIRM, BROWNISH GRAY
15	SS	2	17-13-13 (8 IN.)	26			FILL: SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 1 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, VERY STIFF, BROWNISH GRAY
20	SS	3	12-16-22- 14 (11 IN.)	38			FILL: SANDY SILT, 5-10% GRAVEL TO 0.6 IN. MAXIMUM, 10-15% COARSE TO FINE SAND, HARD, GREENISH GRAY
25	SS	4	22-7-6-7 (6 IN.)	13			FILL: SANDY SILT, 5-10% GRAVEL TO 0.5 IN. MAXIMUM, 15-20% COARSE TO FINE SAND, STIFF, BROWNISH GRAY
30							----- BOTTOM OF FILL @ 28.5 FT TOPSOIL OR PEAT @ 28.5 FT

LEGEND / NOTES

- DATUM IS (MDC SEWER DATUM (MDC - USGS + 105.62 FT)
  - GROUND WATER LEVEL
  - BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". \* INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
  - % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
  - STD. PENETRATION RESISTANCE BLOWS/FT.
  - UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY  
 MWRA



STONE & WEBSTER ENG. CORP.  
 SKETCH No.

APPROVED

DATE

BORING NO.

SHEET

*C. E. K. 10/87*

SF-4

1 OF 2

BORING NO. SF-4

SHEET 2 OF 2

SITE

DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO.

16499.27

ELEVATION (FEET) (1)(2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/ROD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	5-12-14 (10 IN.)	26	CL	CLAY, SLIGHTLY TO MODERATELY PLASTIC, 1-5% COARSE TO FINE SAND, VERY STIFF, GREENISH GRAY
35		SS	6	7-9-13-18 (17 IN.)	22	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY. 1-5% COARSE SAND IN TOP 6 IN.
40		SS	7	4-7-9-10 (12 IN.)	16	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, SEVERAL GRAVEL PARTICLES TO 1 IN. MAXIMUM
45		SS	8	4-6-7-8 (10 IN.)	13	CL- CH	CLAY, MODERATELY TO HIGHLY PLASTIC, FIRM TO STIFF, GREENISH GRAY
50		SS	9	3-5-6-7 (17 IN.)	11	CL- CH	CLAY, SAME AS ABOVE
55		SS	10	10-12-12 (16 IN.)	24	CL	CLAY, MODERATELY PLASTIC, 5-15% COARSE SAND, GREENISH GRAY (TOP 8 IN.)
57.5						CL	SANDY CLAY, SLIGHTLY PLASTIC, 15-30% SLIGHTLY PLASTIC, COARSE TO FINE SAND, STIFF, GREENISH GRAY ----- BOTTOM OF CLAY @ 57.5 FT -----
60		SS	11	17-29-30- 34 (4 IN.)	59	CL	SANDY CLAY, SIMILAR TO ABOVE EXCEPT 15-25% GRAVEL TO 1.0 IN. MAXIMUM
65		SS	12	19-34-34- 57 (8 IN.)	68	CL	SANDY CLAY, SAME AS ABOVE
							END OF BORING AT 67 FT

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH NO.APPROVED  
*W. K. Keller*

DATE

BORING NO.

SF-4

SHEET

2 OF 2

SITE	DEER ISLAND SECONDARY TREATMENT FACILITY	J.O. NO.	16499.27	BORING NO.	SF-5
COORDINATES	N493.720 E746.140	GROUND ELEV. (I)	APPROX +121 FT	SHEET	1 OF 2
INCLINATION	VERTICAL	BEARING	INSPECTOR	HASAN ABEDI	
DATE : START / FINISH	8/27/87 / 8/27/87	CONTRACTOR / DRILLER	EMS/CHARLES REIL		
STATIC GROUNDWATER DEPTH / DATE	(FT) /	DRILL RIG TYPE	MOBILE 8-57		
DEPTH TO BEDROCK	(FT)	TOTAL DEPTH DRILLED	32	(FT)	
METHODS :					
DRILLING SOIL					
SAMPLING SOIL					
DRILLING ROCK					
SPECIAL TESTING OR INSTRUMENTATION					
COMMENTS					

ELEVATION (FEET) (1) (2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RCD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
0							FILL: SANDY SILT, WIDELY GRADED, 5-15% GRAVEL TO 2 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, LIGHT BROWN, DRY
5		SS	1	20-13-14-19 (17 IN.)	27	ML	SANDY SILT, SLIGHTLY PLASTIC, 1-5% GRAVEL TO 1 IN. MAXIMUM, 5-15% MEDIUM TO FINE SAND, LAYERS OF BROWNISH GRAY OVER GREENISH GRAY (GREENISH GRAY LAYER DOES NOT CONTAIN ANY GRAVEL), MOIST.
						SM	SILTY SAND, WIDELY GRADED, 5-15% FINES BROWNISH GRAY, (BOTTOM 3 IN.)
10		SS	2	6-11-13-20 (10 IN.)	24	CL	CLAY, MODERATELY PLASTIC, 2-5% SAND, VERY STIFF, GREENISH GRAY; SEVERAL PIECES OF GRAVEL TO 1.2 IN. MAXIMUM.
15		SS	3	4-6-8-9 (17 IN.)	14	CL	CLAY, SIMILAR TO ABOVE EXCEPT STIFF, SAND SEAM @ 6 IN. FROM TOP
20		SS	4	23-24-24 (2 IN.)	48	CL	SANDY CLAY, SLIGHTLY PLASTIC, 15-25% COARSE TO FINE SAND, HARD GREENISH GRAY, ONE PIECE OF 1 IN. GRAVEL
25		SS	5	24-47-44 (10 IN.)	91	CL	SANDY CLAY, SLIGHTLY PLASTIC, 20-30% GRAVEL TO 1 IN. MAXIMUM, 20-30% COARSE TO FINE SAND, HARD, GREENISH GRAY (TILL)
30							

LEGEND / NOTES	1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT) 2. GROUND WATER LEVEL 3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY. 4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION. 5. STD. PENETRATION RESISTANCE BLOWS/FT. 6. UNIFIED SOIL CLASSIFICATION SYSTEM.	7. SS = SPLIT SPOON  <div style="text-align: center;"> <b>BORING LOG</b>          DEER ISLAND SECONDARY TREATMENT FACILITY          MWRA  <b>STONE &amp; WEBSTER ENG. CORP</b>          SKETCH No.       </div>		
	APPROVED	DATE	BORING NO.	SHEET
			SF-5	1 OF 2



BORING NO. SF-5

SHEET 2 OF 2

SITE

DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO.

16499.27

ELEVATION (FEET) (62)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)
--------------------------	-----------------	--------------------	------------------	--------------------------------	--------------------	---------------------

## SAMPLE DESCRIPTION

SS 6 21-29-34-  
(13 IN.) 63 C L SANDY CLAY, SLIGHTLY PLASTIC, 20-30% GRAVEL TO 1.5 IN. MAXIMUM WIDELY GRADED, 20-30% COARSE  
TO FINE SAND, MOSTLY FINE, HARD GREENISH GRAY.

END OF BORING AT 32 FT

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH No.APPROVED  
*W. E. Kelly*

DATE

BORING NO.  
SF-5SHEET  
2 OF 2



SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27 BORING NO. LF-1  
 COORDINATES N490,570 E747,250 GROUND ELEV. (I) APPROX. 117 FT SHEET 1 OF 2  
 INCLINATION VERTICAL BEARING \_\_\_\_\_ INSPECTOR HASAN ABEDI  
 DATE : START / FINISH 8/28/87 / 8/31/87 CONTRACTOR / DRILLER EMS/CHARLES REIL  
 STATIC GROUNDWATER DEPTH / DATE \_\_\_\_\_ (FT) / \_\_\_\_\_ DRILL RIG TYPE MOBILE 8-57  
 DEPTH TO BEDROCK \_\_\_\_\_ (FT) TOTAL DEPTH DRILLED 56 (FT)  
 METHODS :  
 DRILLING SOIL ROLLER BIT WITH WATER. CASING DRIVEN TO 50 FT  
 SAMPLING SOIL SPLIT SPOON AT 5 FT INTERVALS  
 DRILLING ROCK \_\_\_\_\_  
 SPECIAL TESTING OR INSTRUMENTATION \_\_\_\_\_  
 COMMENTS \_\_\_\_\_

# SAMPLE DESCRIPTION

0  
5  
10  
15  
20  
25  
30

SS 1 15-8-7-3 (9 IN.) IS

SS 2 18-26-33 (17 IN.) 59 CL

SS 3 15-23-30 (17 IN.) 53 CL

SS 4 22-26-37 (13 IN.) 63 ML

FILL: GRAVELLY SAND, WIDELY GRADED, 10-20% GRAVEL TO 1 IN. MAXIMUM, 5-15% FINES, DRY, LOOSE MATERIAL, BROWNISH GRAY, 5-10% COBBLES.

FILL: GRAVELLY SAND, WIDELY GRADED, 10-20% GRAVEL TO 1 IN. MAXIMUM, 5-10% FINES, LOOSE, BROWNISH GRAY.

BOTTOM 2 IN. SANDY CLAY SLIGHTLY TO MOD PLASTIC, 20-30% COARSE TO FINE SAND, STIFF GREENISH GRAY. BOTTOM OF FILL AT 13 FT

SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 20-30% COARSE TO FINE SAND, MOSTLY FINE, HARD BROWNISH GRAY.

SANDY CLAY, SIMILAR TO ABOVE EXCEPT ONE 0.75 IN. GRAVEL PARTICLE.

SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-20% GRAVEL TO 1 IN. MAXIMUM, 20-30% MEDIUM TO FINE SAND, GREENISH GRAY.

LEGEND / NOTES

- DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
- ☒ GROUND WATER LEVEL
- BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140LB HAMMER FALLING 30". \* INDICATES USE OF 300LB HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
- % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
- STD. PENETRATION RESISTANCE BLOWS/FT.
- UNIFIED SOIL CLASSIFICATION SYSTEM.
- SS = SPLIT SPOON

## BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY  
MURA

STONE & WEBSTER ENG. CORP.  
SKETCH NO.

APPROVED CEK DATE \_\_\_\_\_ BORING NO. LF-1 SHEET 1 OF 2

BORING NO. LF-1

SHEET 2 OF 2

SITE

DEER ISLAND SECONDARY TREATMENT FACILITY

J.O. NO.

16499.27

ELEVATION (FEET) (C2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	31-56-65	121		NOTE: NO RECOVERY - 2 ATTEMPTS
	35	SS	6	15-19-25 -38 (13 IN.)	44	CL	<u>SANDY CLAY</u> , SIMILAR TO ABOVE EXCEPT GRAVEL TO 0.8 IN. MAXIMUM.
	40	SS	7	15-20-24 -45 (11 IN.)	44	CL	<u>SANDY CLAY</u> , SAME AS ABOVE
	45	SS	8	116/5 IN. 45-20-23* (5 IN.)		CL	<u>SANDY CLAY</u> , SLIGHTLY PLASTIC, 20-30% GRAVEL TO 1.5 IN. MAXIMUM, 10-30% COARSE TO FINE SAND, GREENISH GRAY
	50	SS	9	14-25-55 -68 (5 IN.)	BO	CL	<u>SANDY CLAY</u> , 5-15% GRAVEL TO 1.5 IN. MAXIMUM, SLIGHTLY PLASTIC, 20-40% COARSE TO FINE SAND, GREENISH GRAY NOTE: A PIECE OF WEATHERED ROCK BLOCKED THE SPOON, LIMITED THE RECOVERY TO 5 IN.
	55	SS	10	40-97-20* (7 IN.)			<u>SANDY CLAY</u> , SAME AS ABOVE
	60						END OF BORING AT 56 FT

NOTE: FOR BORING SUMMARY AND  
LEGEND INFO. SEE SHEET 1.STONE & WEBSTER ENG. CORP.  
SKETCH No.

APPROVED

DATE

BORING NO.

LF-1

SHEET

2 OF 2

SITE NUT ISLAND, MASSACHUSETTS J.O. NO. 16499.27 BORING NO. PSN-1  
 COORDINATES N466,685 E747,410 GROUND ELEV (I) APPROX. 131 FT SHEET 1 OF 3  
 INCLINATION VERTICAL BEARING \_\_\_\_\_ INSPECTOR T. L. ANNARATONE  
 DATE : START / FINISH 4-16-87 / 4-17-87 CONTRACTOR / DRILLER NEW ENGLAND BORING/RANSOELL  
 STATIC GROUNDWATER DEPTH / DATE 13 (FT) / 4-17-87 DRILL RIG TYPE MOBILE DRILL - B-61  
 DEPTH TO BEDROCK 95.5 (FT) TOTAL DEPTH DRILLED 105.5 (FT)  
 METHODS :  
 DRILLING SOIL TRICONE ROLLER BIT WITH WATER  
 SAMPLING SOIL SPLIT SPOON  
 DRILLING ROCK NWD4 CORE BARREL  
 SPECIAL TESTING OR INSTRUMENTATION \_\_\_\_\_  
 COMMENTS \_\_\_\_\_

ELEVATION (FEET) (1)(2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/QCD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
							NO RECOVERY AUGURED TOP TO 10 FT THROUGH 4 IN. THICK ASPHALT PAVEMENT, FILL AND SANDY CLAY
5							
10		SS	1	9-8-12-13 (24")	20	CL	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 25-35% COARSE TO FINE SAND, SOME GRAVEL TO 0.5 IN. MAXIMUM, LIGHT YELLOW BROWN
15		SS	2	14-18-17 (12")	35	SC	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 30-40% COARSE TO FINE SAND, SOME GRAVEL TO 0.25 IN. MAXIMUM, LIGHT BROWN
20		SS	3	13-21-20 (12")	41	SC	SANDY CLAY, SLIGHTLY PLASTIC, 20-25% COARSE TO FINE SAND, SOME GRAVEL TO 0.25 IN. MAXIMUM, BROWN
25							
30							

**LEGEND / NOTES**

- DATUM IS PLANT DATUM, 100 FT ABOVE MEAN LOW TIDE
- GROUND WATER LEVEL 7.55 - SPLIT SPOON
- BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140LB. HAMMER FALLING 30". \* INDICATES USE OF 300LB. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
- % ROCK CORE RECOVERY / ROCK QUALITY DESIGNATION.
- STD. PENETRATION RESISTANCE BLOWS/FT.
- UNIFIED SOIL CLASSIFICATION SYSTEM.

**BORING LOG**

DEER ISLAND SECONDARY TREATMENT FACILITY

MWA

---

STONE & WEBSTER ENG. CORP  
SKETCH NO. \_\_\_\_\_

APPROVED <i>WEX</i>	DATE	BORING NO. PSN-1	SHEET 1 OF 3
------------------------	------	---------------------	-----------------



## **Appendix G**

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**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix G**

**Table of Organization and Position**

## APPENDIX G

### PRELIMINARY TABLE OF ORGANIZATION AND POSITION DESCRIPTIONS

This appendix provides additional supporting information, the suggested functional table of organization, and organizational charts and sample position descriptions for the Deer Island wastewater treatment facilities. The information is provided to supplement and support the discussions of Sections 11.5.1, 11.5.2, and 11.5.3 of this plan.

#### Functional Table of Organization

Three alternative tables of organization were presented to the MWRA staff representatives and the Operations Review Committee (ORC) for consideration as a personnel structure for operation, maintenance and management of the new Deer Island facilities. The organizational structure was selected for the following reasons:

1. Simplicity of management;
2. The "team" concept for accomplishing the work load;
3. Well-divided and realistic spans of control for the management and supervisory teams;
4. Career paths for all employees;
5. Accountability of performance of personnel; and
6. Extensive involvement of the management and supervisory teams, providing strong leadership.

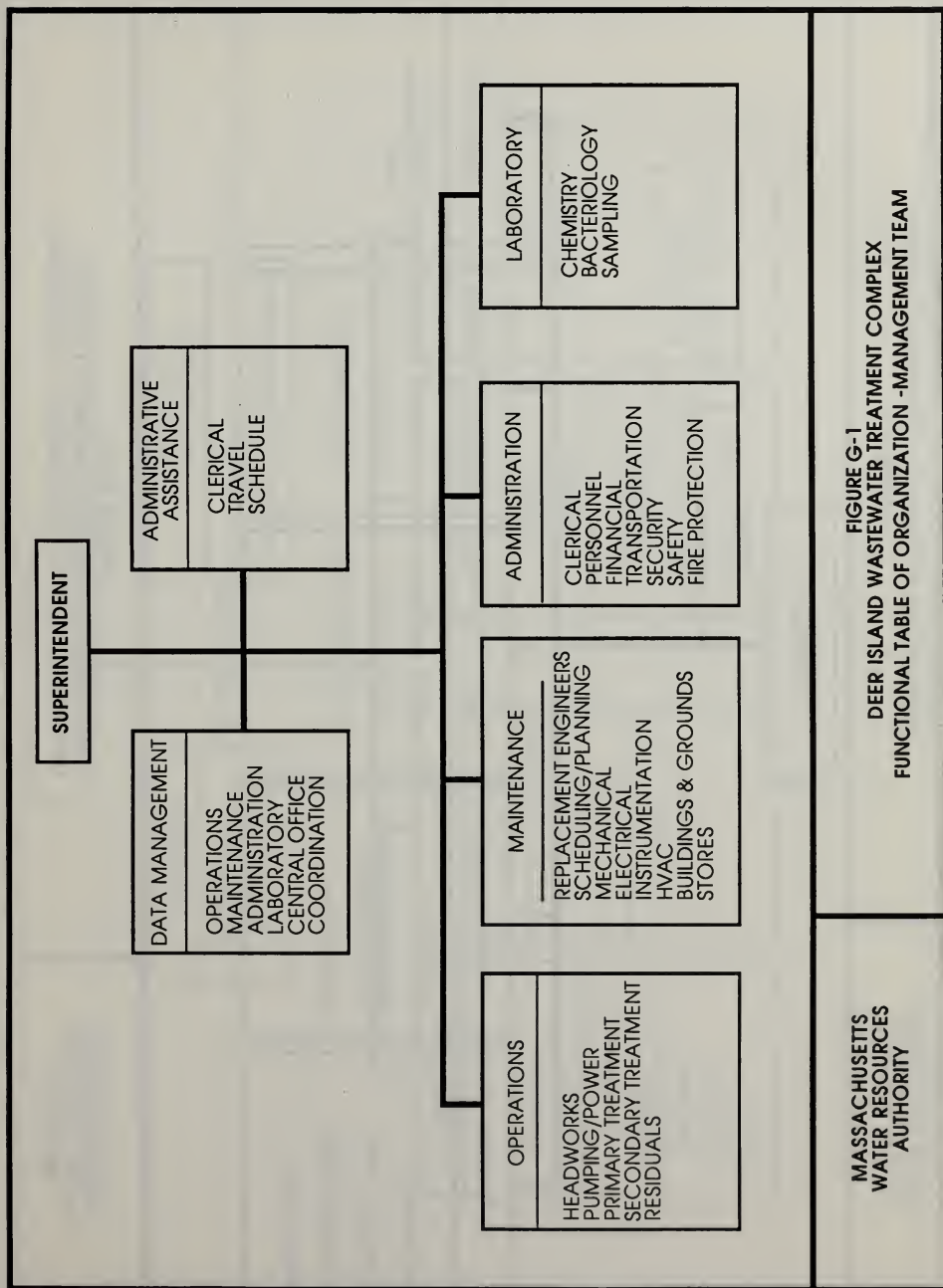
The functional table of organization identifies in the broadest terms what each team, each section, and each function unit is expected to accomplish in order to provide effective operation of the Deer Island treatment facilities. Separate tables of organization were prepared for each of the five sections. These five sections are presented in Figures G-2 through G-5 and are as follows:

Figure G-1	1...Management Team
Figure G-2	2...Operations Section
Figure G-3	3...Maintenance Section
Figure G-4	4...Administration Section
Figure G-5	5...Laboratory Section

#### Organizational Charts

Based on the functions that each table of organization outlines, organizational charts were prepared as shown on Figures G-6 to G-14. The organizational charts show the following:

1. Position titles.
2. The number of personnel required in each individual position title and the total (in parentheses) next to the Superintendent and Division Manager positions.



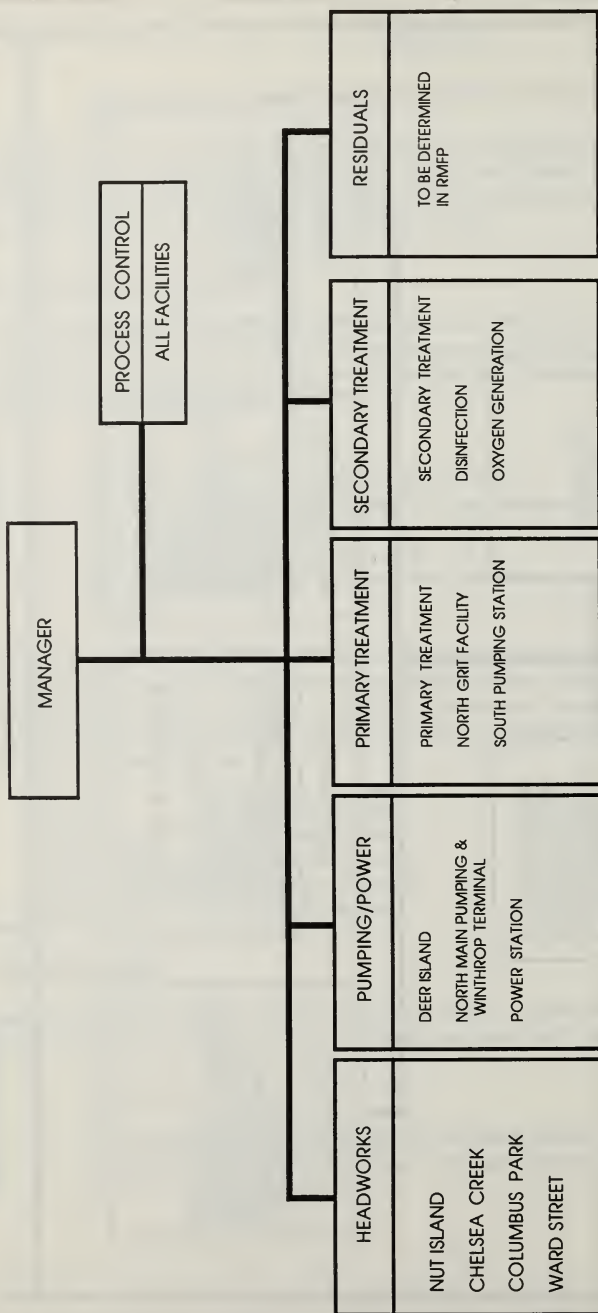


FIGURE G-2  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
FUNCTIONAL TABLE OF ORGANIZATION - OPERATIONS

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

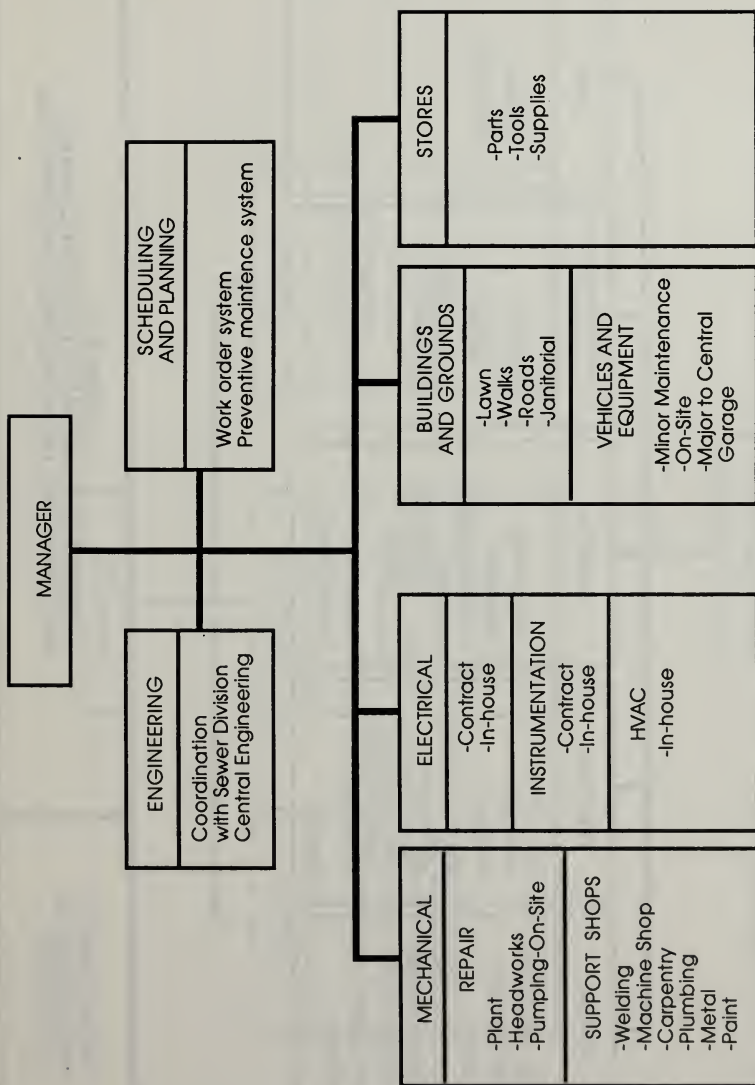


FIGURE G-3  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
FUNCTIONAL TABLE OF ORGANIZATION - MAINTENANCE

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

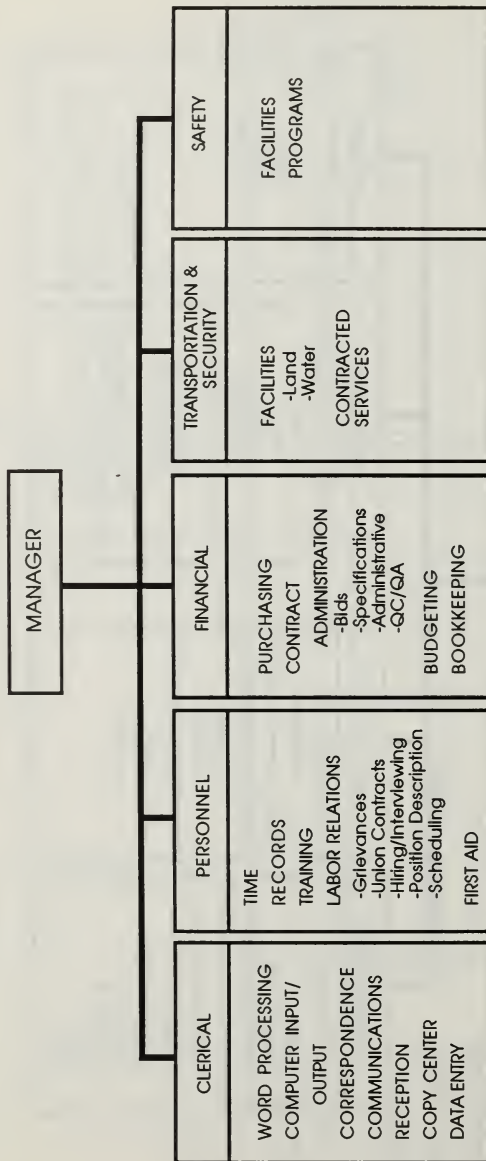


FIGURE G-4  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
FUNCTIONAL TABLE OF ORGANIZATION - ADMINISTRATION

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY



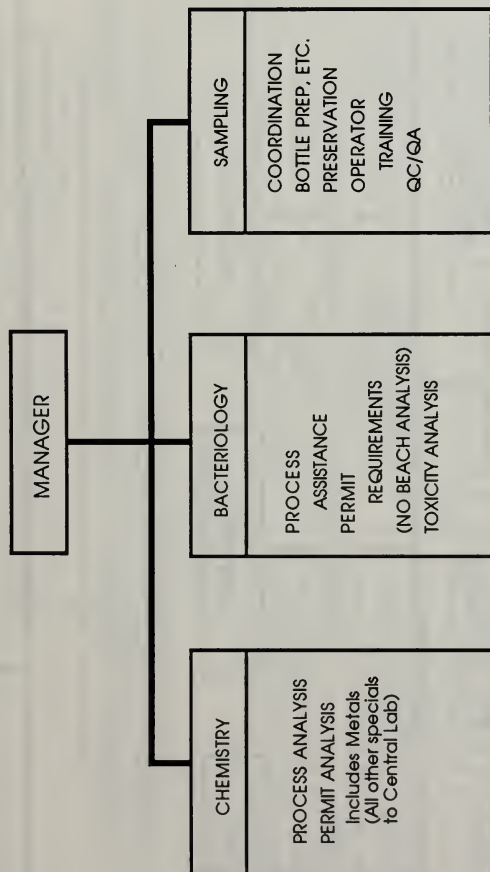


FIGURE G-5  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
FUNCTIONAL TABLE OF ORGANIZATION - LABORATORY (Process Only)

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

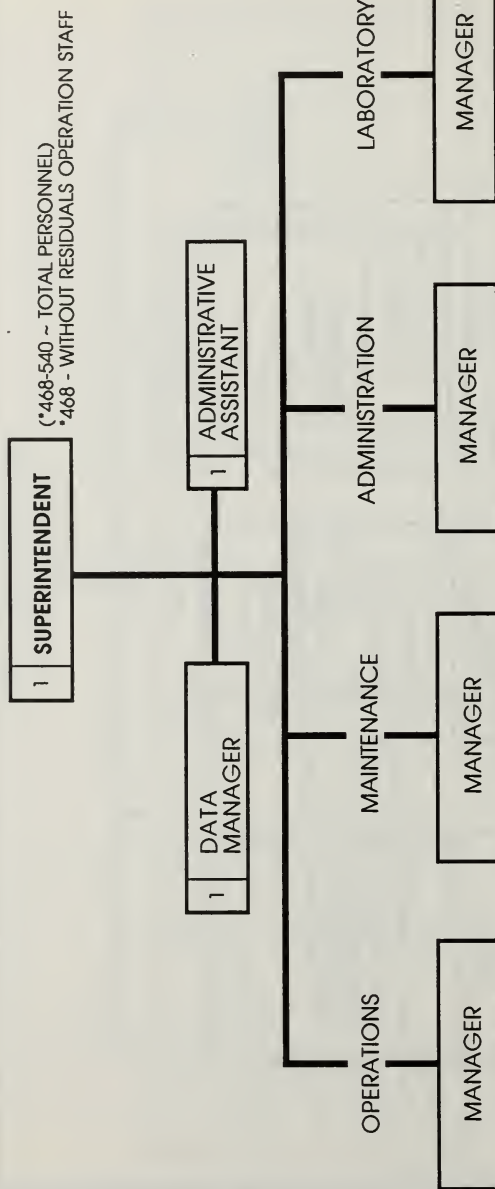


FIGURE G-6  
DEER ISLAND WASTEWATER COMPLEX  
ORGANIZATIONAL CHART - MANAGEMENT TEAM

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

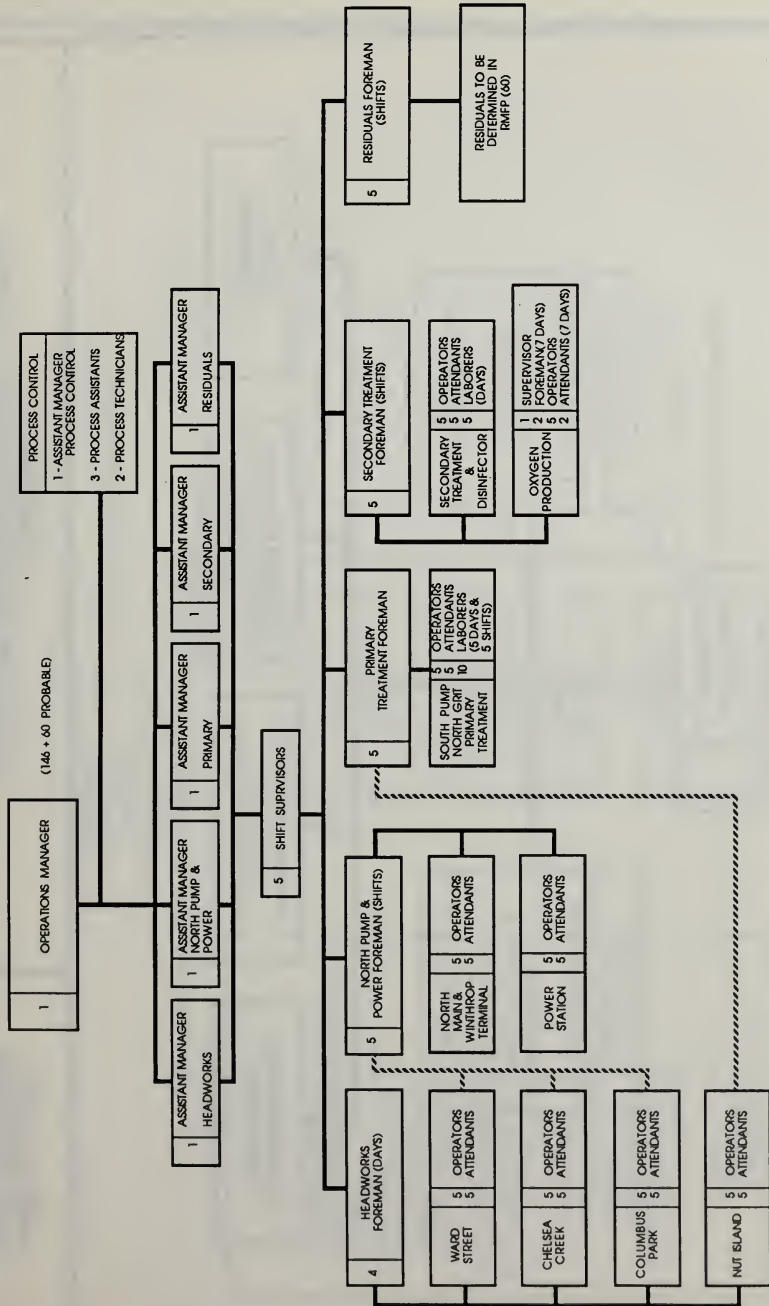
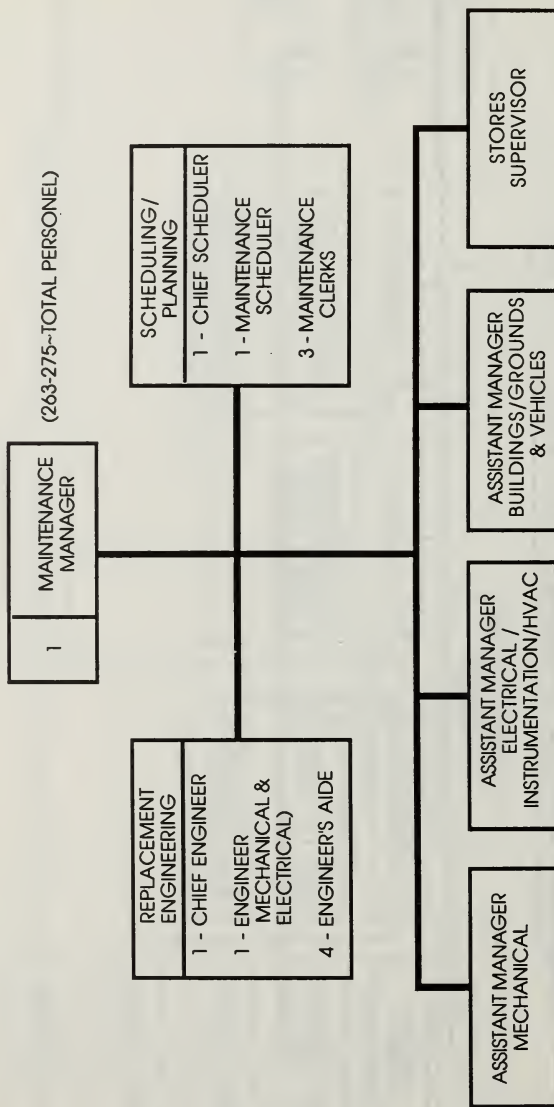


FIGURE G-7  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART - OPERATIONS

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY



**FIGURE G-8**  
**DEER ISLAND WASTEWATER TREATMENT COMPLEX**  
**ORGANIZATIONAL CHART - MAINTENANCE**

**MASSACHUSETTS**  
**WATER RESOURCES**  
**AUTHORITY**

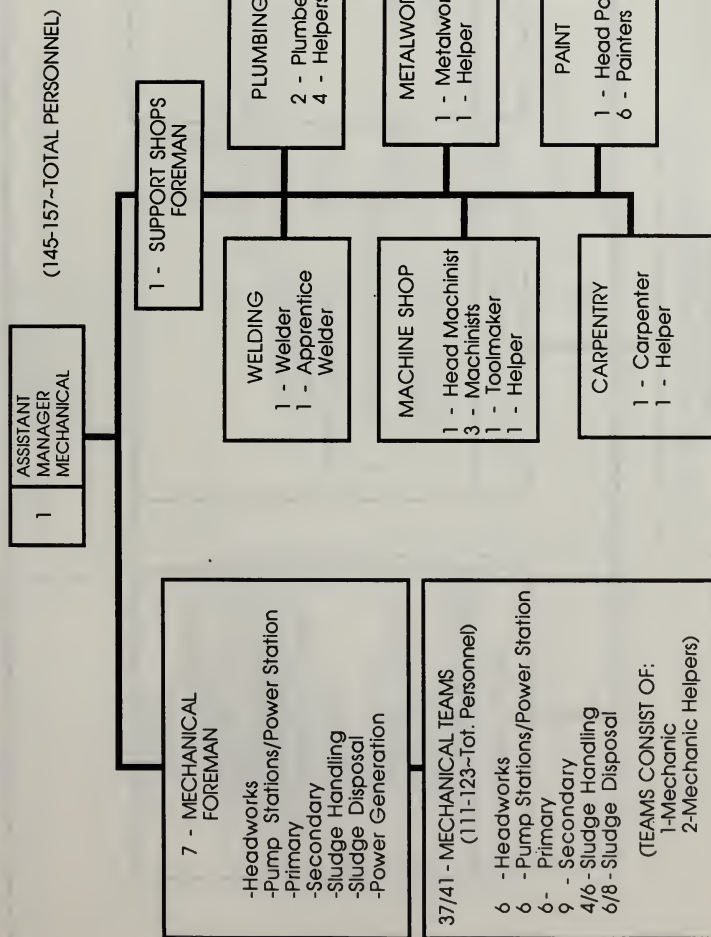


FIGURE G-9  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART - MAINTENANCE - MECHANICAL

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

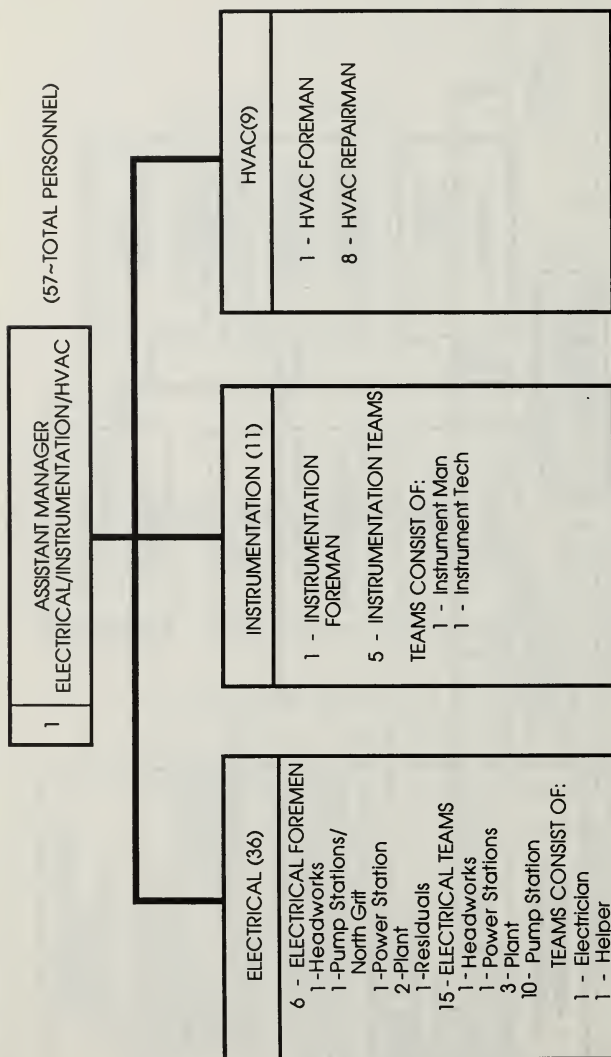


FIGURE G-10  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART  
MAINTENANCE - ELECTRICAL/INSTRUMENTATION/HVAC

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY



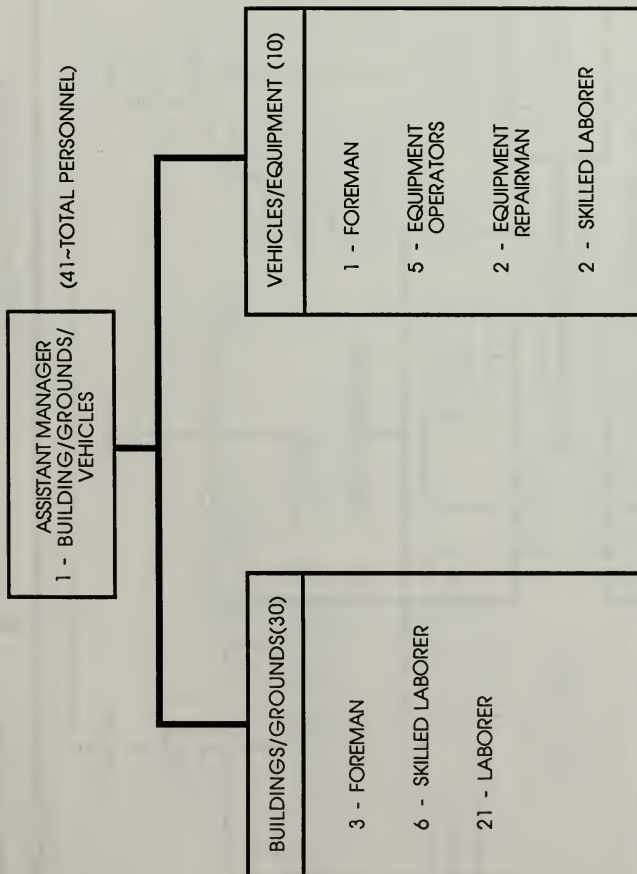
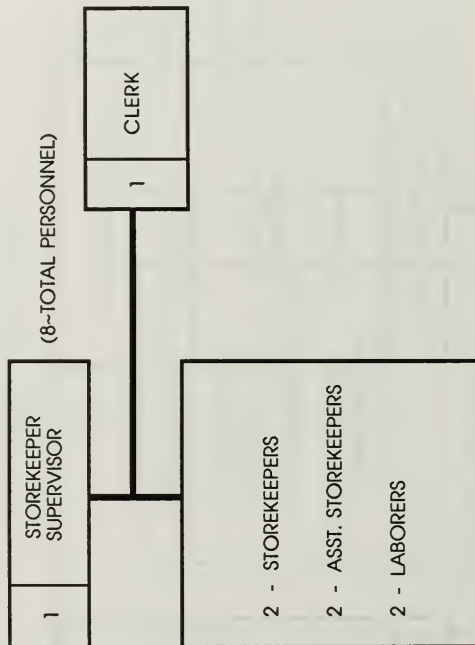


FIG G-11  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART - MAINTENANCE - BUILDINGS/GROUNDS/VEHICLES

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY



MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

FIGURE G-12  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART - MAINTENANCE - STORES

(40-TOTAL PERSONNEL)

1  
ADMINISTRATION  
MANAGER

CLERICAL

1  
PRINCIPAL  
CLERK

1  
COPY  
CLERK

2  
WORD  
PROCESS

1  
RECEPTION

2  
TYPING  
CLERKS

2  
DATA ENTRY

PERSONNEL

1  
DIRECTOR

2  
RECORDS  
CLERKS

2  
TIME  
CLERKS

1  
TRAINING  
OFFICER

2  
TRAINING  
ASSISTANT

1  
CLERK

1  
LABOR  
RELATIONS

1  
ASSISTANT

2  
CLERKS

FIRST AID

1  
NURSE

1  
AIDE

2  
PURCHASING  
AGENT

2  
CLERKS

1  
DIRECTOR

1  
BUDGET  
MANAGER

1  
BOOK-  
KEEPER

1  
CONTRACT  
ADMINISTRATOR

1  
ASSISTANT

FINANCIAL

TRANSPORTATION &  
SECURITY

1  
SUPERVISOR

2  
ASSISTANT

SAFETY & FIRE  
PROTECTION

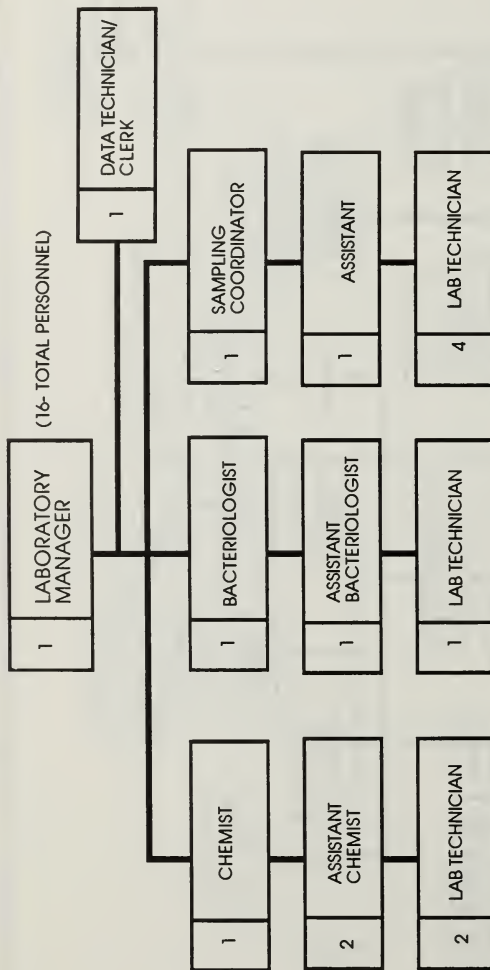
1  
SAFETY  
OFFICER

1  
SAFETY  
ASSISTANT

1  
FIRE CHIEF

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

FIGURE G-13  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART-ADMINISTRATION



\* SAMPLING SYSTEM INCLUDING THE HEAD WORKS, IPP AND SLUDGE IS TO BE DETERMINED AT A LATER DATE AND MIGHT EFFECT THIS ORGANIZATION STRUCTURE..

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

FIGURE G-14  
DEER ISLAND WASTEWATER TREATMENT COMPLEX  
ORGANIZATIONAL CHART-LABORATORY (Process Only)

3. The structure of the teams and sections that establishes a chain of command and potential career path for the individual employees.
4. The structure for holding individual positions accountable for performance.

#### Discussion of Individual Sections

The Superintendent has two staff assistants and four section managers under his supervision. It is intended that the Superintendent will set the goals, place overall priorities and, in general, plan and direct the Deer Island Facilities through the management staff to accomplish the intended mission and meet the legal requirements of the regulatory permits.

1. The Operations Section (Figure G-7) will operate and control all equipment to accomplish the permit requirements. This includes the four headworks, pumping, grit removal, power generation, primary and secondary treatment of the wastewater, disinfection of the treated wastewater, and concentration, conditioning and disposal of removed residuals.

The Operations Manager will supervise a process control unit as a staff function and will have five assistant managers under his direction to accomplish the necessary work tasks. The five assistant managers will work through the various foremen assigned to their units to identify work tasks and assign duties to staff personnel to effectively accomplish the unit's goals. The shift supervisors will be informed of the goals and assigned tasks by the assistant managers and will serve as individual shift leaders to coordinate all the group's efforts. The foremen on assigned shifts will work directly with, and assist, the shift supervisors in this coordinating effort.

The process control staff will be responsible for proper operational direction of the treatment process. This group will serve under the direct supervision of the operations manager. They will be the only group that can direct actual changes in the process control of the facility operations. They will be held accountable by the operations manager for meeting treatment requirements through proper process control directions.

The operations staff is divided within the units to provide sufficient personnel to accomplish the necessary tasks to achieve effective and efficient operations. It is recommended that the staff, the foremen and the assistant managers be rotated from unit to unit on a regular periodic basis to broaden their skills and improve morale.

2. The Maintenance Section (Figure G-8) is divided into four sub-function specialty units. This section serves as a service staff for the operations section. Their role is to keep all equipment in operating condition so that it is available to the operations section when required. They will provide mechanical, electrical, instrumentation, and HVAC maintenance, buildings and grounds and vehicular maintenance and repair



services. A stores unit has been established to provide tools, supplies, parts, and other necessities for use by personnel in the performance of their duties.

The Maintenance Manager supervises two staff units to assist with special tasks and provide support for the proper functioning of the section. The replacement engineering unit will provide technical support for special maintenance tasks. They will also coordinate and act as an independent support function for Sewer Division central engineering, located in the MWRA central offices. The scheduling/planning group is responsible for the proper functioning of the maintenance management system (MMS). They will receive all maintenance requests, schedule them with one of the four function units' assistant managers, plan any required inter-unit action, check on parts availability, issue and track work orders, and maintain the MMS record system.

The maintenance staff including mechanical, electrical, instrumentation and HVAC maintenance personnel is divided into specialty function units to accomplish the various tasks necessary to ensure availability of equipment needed to achieve proper operations. The various units are divided into teams that provide personnel to accomplish work order assigned tasks. Each of the teams is assigned work by a foreman who will be responsible for the productivity and quality of work performed by the individual teams. The assistant manager's span of control includes only the foreman assigned to his specialty unit, and he will be responsible for accomplishment of tasks by the foreman's assigned teams.

3. The Administration Section (Figure G-13) will support the large staff of the facility by providing on-site administrative services as well as coordination with the MWRA Sewer Division central office administration staff. These administrative services include clerical duties, records control and storage, time-keeping issues, labor relations, training of personnel, first aid services, purchasing, budget management, contracts management, personnel safety, fire protection, and transportation and security coordination.

The Administration Manager is responsible for these functions and works through five supervisors or directors to accomplish the tasks.

Each supervisor or director has appropriate staff assigned to accomplish the unit's responsibilities. The clerical unit will provide all reception and clerical services for the facilities. The personnel unit will control timekeeping, labor relations, first aid and training program development. The financial unit controls all purchasing, budget preparation and control and contract development, performance and quality control.

The safety and fire protection unit will prepare and perform continuous safety program development and execution plus fire protection for the facilities. The transportation and security unit will coordinate all transportation and site security issues.



4. The Laboratory Section (Figure G-14) is established to provide all process control and on-site permit requirement analysis and sampling coordination. They will also provide laboratory data input to the process control unit in the operations section. The section is divided into three functional units (i.e., chemical analysis, bacteriological analysis, and sampling coordination).

The laboratory manager has a span of control of three unit leaders and has a staff position assigned to input data to the data management system as required.

#### Position Descriptions

Position descriptions, the guiding concept behind the creation of positions, and what elements and information should be included in position descriptions are discussed in Section 11.5.1 of this plan. A few sample descriptions are included here for illustrative purposes only, as shown on the following pages.

## SAMPLE DESCRIPTION - NOT FOR USE

### MAINTENANCE MANAGER

#### GENERAL STATEMENT OF DUTIES

Participates as a part of the Deer Island management team and is responsible for directing the maintenance department, incorporating all mechanical, electrical, instrumentation HVAC, buildings and grounds, and vehicular maintenance of the facilities, including the storeroom for inventories of supplies and parts. Directs the maintenance staff, including the planning and scheduling of all maintenance work both corrective and preventive, and replacement engineering units. Directs the effective use of employees, equipment and material, within an approved budget and quality standard, through assistant managers and supervisors. Participates in plant-wide operational and maintenance coordination activities. Recommends and implements maintenance procedures, and equipment when required. Directs the training of maintenance personnel, resolves personnel problems, grievances and issues when required. Directs preparation of work schedules, and enforces work rules in accordance with established policies and practices. Makes spot inspections of plant equipment throughout the facility to check that standard maintenance procedures are being followed. Responsible for the implementation of safety practices for maintenance personnel. Undertakes special studies and other assignments as required.

#### SUPERVISION RECEIVED

Works under the direct supervision of the Superintendent.

#### SUPERVISION EXERCISED

Supervises all maintenance-related personnel through the assistant managers and supervisors and others assigned to the maintenance department from time to time.

#### EXAMPLES OF DUTIES

- o Directs the mechanical, electrical, and buildings and grounds maintenance of the complex and the support functions of replacement engineering, scheduling/planning and stores.
- o Advises the Superintendent on all matters pertaining to plant maintenance to ensure efficient and economical functioning of all plant facilities and equipment.

- o Reviews the maintenance needs of the plant and develops procedures and programs for accomplishing this maintenance including the preventive maintenance of plant equipment and facilities. Makes personal observations to analyze plant and equipment conditions and recommends corrective measures when and where needed. Investigates, diagnoses, and recommends correction of abnormalities occurring in the plant and plant equipment.
- o Responsible for planning and scheduling the maintenance work of the plant to make maximum and effective use of employees, equipment and material within an approved budget and quality standards.
- o Estimates workforce requirements, and recommends selection of employees necessary to perform the work.
- o Directs the training of maintenance personnel, resolves personnel problems, grievances and other related issues.
- o Makes spot inspections throughout the plant to check that standard maintenance procedures are being followed.
- o Makes inspections throughout the plant to check compliance with the plant safety program and to detect existing or potentially unsafe or unhealthy working procedures, equipment or conditions.
- o Enforces work rules in accordance with established policies and practices.
- o Assists in administering plant fiscal matters and participates in the preparation of reports and budget, reviews maintenance records and data, and develops recommendations.
- o Participates in plant-wide projects aimed at the improvement of plant operations, maintenance and management.
- o Prepares, or directs preparation of, records and reports concerning plant maintenance as required.
- o Establishes procedures for action and recommendations for approval of promotions, merit increases, transfers, leaves of absence, disciplinary measures and other personnel status changes.
- o Trains an understudy to assume the Maintenance Manager's position in the event of his/her absence or promotion.
- o Responsible for the preparation and dissemination of data and reports related to the maintenance department.

## SPECIAL DUTIES

None

## ENTRANCE REQUIREMENTS AND QUALIFICATIONS

- o A minimum of fifteen (15) years of experience in the maintenance and repair of mechanical equipment similar to that installed in a wastewater treatment plant showing progressive steps of increased responsibility.
- o Must have at least six (6) years of experience as a working supervisor or foreman.
- o Considerable knowledge of the occupational hazards and safety precautions pertaining to all phases of wastewater treatment plant maintenance.
- o Additional work or supervisory experience in managing a maintenance management system is beneficial.
- o Ability to direct a wide variety of maintenance personnel.
- o A thorough knowledge of maintenance systems and procedures in a wastewater treatment facility.
- o Ability to plan, organize, direct and coordinate assigned maintenance projects.
- o Working knowledge of the maintenance of buildings and grounds.
- o A career-minded interest in the maintenance of wastewater treatment facilities.
- o Ability to provide positive leadership and management control to the maintenance personnel by his/her actions and examples.
- o Ability to accept instructions, formulate plans of action, implement changes and ensure their compliance.
- o Must present a neat, courteous and professional appearance and attitude at all times.
- o Must be self-motivated.

## SUBSTITUTION

- o A Bachelor of Science or Bachelor of Engineering degree from an approved college or university may be considered a substitute for five (5) years of maintenance experience.

SPECIAL WORKING CONDITIONS

None

SALARY CLASSIFICATION

Non-Union - Supervisory

## SAMPLE DESCRIPTION - NOT FOR USE

### SHIFT SUPERVISOR

#### GENERAL STATEMENT OF DUTIES

On an assigned shift, has overall responsibility for the safe and efficient operation of the Deer Island facilities. Supervises a staff of foremen, operators and/or attendants. Oversees adjustment of plant processes as directed by the process control unit. Makes regular inspections throughout the plant to ensure that work is being performed and that standard operating procedures are being followed as assigned by the foreman overseeing that unit of the plant. Has knowledge of condition of all plant equipment in the event of emergency. Participates in the training of operations personnel. Ensures that the Deer Island safety, QA/QC procedures, and work rules are followed in accordance with established practices and procedures. Prepares and checks logs and reports as required. Is responsible for the operation of the complex on shifts as assigned and provides written instructions for meeting the unit goals for process control and work station housekeeping.

#### SUPERVISION RECEIVED

Works under the direct supervision of the Operations Manager and Assistant Unit Operations Managers.

#### SUPERVISION EXERCISED

Supervises, on an assigned shift, a staff of foremen, operators and/or attendants. May, on occasion, supervise a number of wastewater treatment plant mechanics and/or laborers.

#### EXAMPLES OF DUTIES

- o Supervises the operation of the complex following the guidelines established in the Process Control Unit on an assigned shift.
- o Directs the detailed operation and housekeeping tasks through the unit foreman of one of four units of the plant by discussing the process control guidelines, housekeeping schedules, hosing schedules, and log sheets. Evaluates results to assure maximum performance of the facilities and the operator/attendants assigned.
- o Assigns duties to a staff of wastewater treatment plant operators and/or attendants through the unit foreman.
- o Makes regular inspections throughout the plant, to ensure that work is being performed and that standard operating procedures are being followed, to check the operation of the



plant equipment, and to detect existing or potentially unsafe or unhealthy operating procedures, equipment or conditions.

- o Prepares, analyzes and routes, according to the Management Information System (MIS), log sheets and reports required to properly control the various units of the plant.
- o Reviews and submits maintenance work orders related to equipment malfunctions and unsafe conditions.
- o Places into effect, according to the Emergency Operating Plan (EOP), in the event of any emergency, the appropriate corrective procedures to maintain and/or restore operating conditions.
- o Participates in the training of foremen, operators/attendants, including instruction in the proper use of safety equipment, first aid kits, oxygen breathing apparatus, resuscitator, firefighting equipment, gas detection devices, etc.

#### SPECIAL DUTIES

None

#### ENTRANCE REQUIREMENTS AND QUALIFICATIONS

- o At least eight (8) years of full-time, paid experience in positions of increasing responsibility in the operation of wastewater treatment plants, at least three (3) years of which shall be in "direct responsible charge" of an operating shift in a treatment plant of similar complexity.
- o Possession of, or eligibility for, a Massachusetts Class VI public sewage treatment plant operator license.
- o An interest in the supervision of employees in the operation of a wastewater treatment plant.
- o Considerable knowledge and experience in the operation of a wastewater treatment plant with sophisticated treatment and sludge handling processes.
- o Ability to supervise a wide variety of personnel and personalities.
- o Ability to plan, organize, direct and coordinate assigned projects.
- o Must be reliable, thorough, dependable and able to work both independently and as head of a team.
- o Must present neat, courteous and professional appearance and attitude at all times.

- o Gives positive leadership to the operations personnel by his/her actions and example.
- o Must be extremely safety-conscious when performing duties.
- o Must be able to accept instruction, formulate plans of action, and ensure their compliance.
- o Must be in good physical condition.

#### SUBSTITUTION

- o Successful completion of three (3) years of full-time, or equivalent part-time training, in a recognized technical institute or college with courses in the area of water and wastewater technology may be substituted for the required experience on the basis of one full school year for one year of the required experience.

#### SPECIAL WORKING CONDITIONS

Under normal and abnormal working conditions, there is the possibility of exposure to weather, fumes, odors, dust, toxic gases and chlorine.

#### SALARY CLASSIFICATION

Non-Union - Supervisory

## SAMPLE DESCRIPTION - NOT FOR USE

### OPERATOR

#### GENERAL STATEMENT OF DUTIES

Under minimal supervision, on an assigned shift, has responsibility for performing operational procedures, minor maintenance and housekeeping tasks at the treatment and pumping facilities. Collects wastewater samples, maintains required log sheets, and operates a wide variety of mechanical and electrical equipment used in the treatment processes. Makes regular and scheduled inspections throughout the assigned area, recognizes, corrects or reports potential interruption/failure of equipment or process to the shift or headworks foreman. Performs and/or assists shift foreman in operational procedures during emergency conditions. Responsible for the good housekeeping of equipment and buildings in the assigned area.

#### SUPERVISION RECEIVED

Works under the direct supervision of the Shift or Headworks Foreman.

#### SUPERVISION EXERCISED

None.

#### EXAMPLES OF DUTIES

- o Operates wastewater treatment and sludge processing equipment to control wastewater and sludge flow streams to maintain effluent compliance standards.
- o Collects composite and grab samples as instructed.
- o Maintains shift log and records meter and gauge readings.
- o Monitors and observes variations in operating conditions and interprets meter, gauge readings, control panels and test results to determine processing equipment requirements.
- o Operates valves and gates either manually or by remote control; starts and stops pumps to control and adjust flow and treatment processes.
- o Manually operates and uses rakes, shovels, forks, and other similar tools in collecting and removing trash, screenings, grit and other materials from the wastestream to collection bins for disposal.
- o Assists shift supervisors and shift foreman in controlling the wastewater treatment process during routine and emergency conditions.

- o Performs the application and preparation of chemical solutions and the operation of chemical equipment and appurtenances in accordance with needs.
- o Makes inspections as required to observe and check the operation and condition of equipment; detect and report faulty equipment operation, malfunction and/or breakdowns to the shift or headworks foreman.
- o Responsible for the good housekeeping of equipment and buildings in the assigned area as well as other employee areas of the facility.
- o Assists in the loading/unloading of chemical and other deliveries.
- o Follows the established safety procedures.
- o Follows the established QA/QC procedures for sample collections.
- o Ensures that safety instruments and equipment under his/her care are maintained in working order, cleaned and stored properly.
- o Prepares and submits maintenance work orders relating to equipment malfunctions and unsafe conditions to the shift foreman, as a part of the Maintenance Management System (MMS).
- o Performs related duties as assigned.

### SPECIAL DUTIES

Volunteer Firefighter

### ENTRANCE REQUIREMENTS AND QUALIFICATIONS

- o At least five (5) years of full-time paid experience in positions of increasing responsibility in a wastewater treatment facility.
- o Possession of a Massachusetts Class III public wastewater treatment plant operator license.
- o Previous experience in a water or wastewater treatment facility or related industry highly preferred.
- o Previous education or training in a recognized technical institute or college in an area of study or training related to wastewater treatment operations is highly preferred.
- o Must present a neat, courteous and professional appearance and attitude at all times.

- o Must be able to follow oral and written instructions.

- o Must be self-motivated.

#### SPECIAL WORKING CONDITIONS

Under normal and abnormal working conditions, there is the possibility of exposure to weather, fumes, odors, dust, toxic gases and chlorine.

#### SALARY CLASSIFICATION

Union

## SAMPLE DESCRIPTION - NOT FOR USE

### LABORER

#### GENERAL STATEMENT OF DUTIES

Performs heavy manual tasks requiring some specialized skills or knowledge in one or more of the mechanical trades; performs related work as required. Works in accordance with established work and safety practices.

#### SUPERVISION RECEIVED

Works under the supervision of employees of higher grade, including foreman, mechanics, electricians, storekeeper/scheduler, operators, and other personnel assigned.

#### SUPERVISION EXERCISED

None

#### EXAMPLES OF DUTIES

1. Performs heavy manual tasks requiring some specialized skill or knowledge.
2. Assists mechanics, operating personnel or other tradesman engaged in the maintenance and operation of the treatment plant and related facilities.
3. Removes trash and other debris to storage hoppers; maintains work area and equipment in a clean and orderly condition.
4. Loads, unloads, moves and transports materials, equipment, freight and supplies; assists in the handling and storage of stock.
5. Operates motor vehicles, hoists and portable equipment as required; cleans, washes, gases, oils and greases vehicles and equipment.
6. Works on grounds, buildings and roadways; sands roads and walkways; cleans drains, manholes and sumps.
7. Cuts, fertilizes, waters, trims, rolls and rakes lawns; prunes trees and shrubs.
8. Works on snow removal team during and after snow storms.
9. Assists in the upkeep of buildings and grounds.



10. May erect and work from scaffolding and ladders.
11. Performs other duties as assigned.

### SPECIAL DUTIES

Volunteer Firefighter

### ENTRANCE REQUIREMENTS

1. Ability to perform tasks that are assigned by supervisors.
2. Experience in labor tasks highly preferred.
3. Must possess a valid driver's license and a safe driving record.
4. Some knowledge of the use of common hand tools.
5. Some knowledge of construction and maintenance materials.
6. Ability to operate power saws, winches, cement mixers, compressors and other similar equipment.
7. Ability to operate automotive trucks and equipment.
8. Must have the ability to perform manual labor for extended periods and under varying climatic conditions.
9. Must be reliable, thorough and dependable with the ability to work both independently and as part of a team.
10. Must present a neat, courteous, and professional appearance and attitude at all times.
11. Must receive directions well and be willing to learn.
12. Ability to successfully carry out detailed oral and written instructions.
13. Must be thoroughly safety conscious when performing duties.
14. Must be self-motivated.

### SPECIAL WORKING CONDITIONS

Under normal and abnormal working conditions, there is the possibility of exposure to weather, fumes, odors, dust, toxic gases and chlorine.

### SALARY CLASSIFICATIONS

Union

## SAMPLE DESCRIPTION - NOT FOR USE

### MECHANIC

#### GENERAL STATEMENT OF DUTIES

Performs the inspection, overhaul, repair, testing and maintenance of a wide variety of mechanical equipment. Implements corrective maintenance and preventive maintenance procedures. Recommends and implements improvements and modifications to plant machinery and equipment. Performs tasks requiring some specialized skill or knowledge relating to the maintenance or operations of the treatment plant and related facilities. Works in accordance with established work and safety practices.

#### SUPERVISION RECEIVED

Works under the direct supervision of a Mechanical Foreman.

#### SUPERVISION EXERCISED

Supervises one or more Mechanic Helpers, Laborers, or others assigned as helpers.

#### EXAMPLES OF DUTIES

1. Performs the rebuilding and maintenance of flights, chains, belts, sprockets, shafts, bearings and rails of sludge, grit, scum collecting and conveying systems as used in sedimentation tanks, mechanically-cleaned bar screens and other plant processes.
2. Overhauls pumps, renews pump components, repacks stuffing boxes, replaces shafts, bearings, couplings and packings.
3. Cleans, overhauls and maintains pumps, chlorination equipment and telescoping sludge valves; renews ball bearings, lubricant seals and retainers; overhauls motor reduction gears; renews internal parts as directed.
4. Cleans, overhauls and maintains chemical feed equipment, eductors, vibratory feeders, mixers, rotary gate valves, and chemical solution feed pumps.
5. Overhauls, removes and maintains shaft type couplings as well as pneumatic members, rubber bushings and spiders, in an approved manner.
6. Assists in overhaul and maintenance of engines; changes lubricants and filters at scheduled intervals; renews internal shafts, gears, bearings, bushings, retainers and seals as directed.

7. Maintains and repairs gas and air compressors, reduction gears, boilers, oil and gas burners, chlorine feeding equipment, valves, heat exchangers, centrifugal pumps, air or gas storage tanks, portable gasoline engine powered pumps, compressors and welders.
8. Maintains plant automotive, truck and snowplow equipment as assigned.
9. May erect and work from scaffolding and ladders.
10. Performs other duties as assigned by the supervisor.

### SPECIAL DUTIES

Volunteer Firefighter

### ENTRANCE REQUIREMENTS AND QUALIFICATIONS

1. A minimum of five (5) years' training and experience in the maintenance and repair of heavy mechanical equipment as used in a wastewater treatment plant.
2. Must have served an 8,000 hour state approved mechanical apprenticeship program or equivalent.
3. Considerable knowledge of the occupational hazards and safety precautions pertaining to all phases of plant maintenance.
4. Must be able to read blueprints.
5. Must be able to operate shop equipment including drill presses and other standard machine shop tools.
6. A career-minded interest in the maintenance and repair of mechanical and electrical equipment.
7. Considerable knowledge of the proper use of hand and power tools.
8. Ability to perform orderly disassembly and reassembly of complex precision machinery and components.
9. Ability to properly supervise others assigned as helpers.
10. Strength and agility necessary to maintain and repair heavy, crude machinery.
11. Knowledge of rigging, hoisting and tackle procedures.

## **Appendix I**

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## APPENDIX I

### WATER SUPPLY

#### 1.0 INTRODUCTION

The Deer Island Secondary Treatment facilities will require a sufficient supply of potable water for the sanitary needs of the workers and for laboratory needs. In addition, potable water will be used for critical mechanical needs and for critical chemical mixing.

The purpose of this report is to discuss the plant's water requirements and the alternatives available to provide the required water.

#### 2.0 WATER REQUIREMENTS

Potable water is presently used at the treatment plant for toilets, sinks, drinking fountains, sludge heaters, engine cooling, equipment flushing and washdown, and seal water. Average and maximum present consumptions are 0.1 million gallons per day (mgd) and 0.2 mgd, respectively.

For the new treatment facility, water use will increase to an average consumption of 1.0 mgd and a maximum consumption of 2.0 mgd. The amount of potable water utilized at other large treatment facilities is comparable. The usage at other treatment facilities is influenced by the availability of potable water and the quality of plant effluent. Four similar facilities, their design size, and potable water usage are shown in Table I-1:

TABLE I-1

#### TREATMENT PLANT WATER USE

<u>Plant</u>	<u>Treatment Capacity</u>	<u>Potable Water</u>
Chicago Calumet Plant	220 mgd	2.4 mgd
Chicago West South West	1200 mgd	0.7 mgd
District of Columbia WPCP	370 mgd	1.0 mgd
Blue Plains		
County Sanitation District of Los Angeles	350 mgd	1.2 mgd

In order to limit the consumption of potable water to a maximum of 2.0 mgd, the Deer Island facility will be designed to reuse treated secondary effluent for those purposes which do not require potable quality water. Nonpotable water is designated "plant water" and will be used for pass-through engine cooling, process equipment flushing, and equipment washdown. Plant water will be provided by a 45 mgd (31,250 gallons per minute) plant water pump station

discharging directly to the plant water distribution system. The plant water pump station will consist of five pumps in parallel, and normally will operate with three or fewer pumps on-line, one pump on standby, and one pump available for maintenance.

The uses for plant water will change as the plant progresses through the phases of construction, primary plant operation, and ultimately, secondary plant operation. During construction of the primary facilities, secondary effluent will not be available to supply the noncritical primary plant processes and potable water will be used. The largest identified water use is for pass-through engine cooling water used for the recommended power facilities: these are configured to utilize primary effluent. Upon completion of secondary facilities, these noncritical primary plant process water requirements can be transferred to the process water system.

It is recommended that, in addition to potable water for daily needs, a supply of potable water should also be available for firefighting purposes. It is unlikely that a municipal fire department, either Boston's or Winthrop's, would connect its fire hoses to anything but a potable water supply. The required volume of water for firefighting purposes is determined by the size and height of a structure, the flammability of the structure and its contents, and the presence or absence of a sprinkler system. In order to reduce the amount of water necessary for firefighting, it was assumed that all critical structures and gallery areas will be protected by sprinkler systems. It was also assumed that the maximum required fire flow is 3,000 gpm (4.32 mgd). This is adequate for a two-storey building constructed of noncombustible materials, with exterior dimensions of 150 ft by 150 ft. The fire flow must be available for a three-hour duration and must be available either from the water main supplying the site or from nearby storage. Three thousand gallons per minute for three hours equals 540,000 gallons.

### 3.0 DATUM PLANES

All elevations in this memorandum are shown in Boston City Base Datum (BCBD) which is the datum used by the Massachusetts Water Resources Authority's Water Division. The relationship to other datums are as follows:

<u>To Convert From</u>	<u>To</u>	
Boston City Base (BCBD)	MDC Sewer Datum (MDCSD)	Add 99.97 ft
<u>To Convert From</u>	<u>To</u>	
BCBD	U.S. Geological Survey (USGS)	Subtract 5.65 ft

To Convert FromTo

USGS

MDCSD

Add 105.12 ft

To Convert FromTo

BCBD

Pounds per square inch

BCBD in feet =

2.289 h + 31.33 psi

where h =

head in psi

#### 4.0 EXISTING WATER SUPPLY

Potable water is currently supplied to Deer Island from the Town of Winthrop's water system. The Town's system is supplied by the MWRA's Northern High Distribution System (NHDS). Water is delivered to this system from shafts 9, 9A, and the Spot Pond pumping station.

The Winthrop connection to the NHDS, located at the Revere line, is known as MWRA Meter 41. This consists of a 20-inch main, a 16-inch main, pressure reducing valves, and a meter. At present only one of the lines, typically the 16-inch line, is open. Currently, the hydraulic grade line at Meter 41 is approximately elevation 240 Boston City Base Datum (BCBD) under average-day demands and drops to approximately elevation 200 BCBD under peak flows. This section of the Northern High System was analyzed by the MDC in 1981 for the probable worst case condition of a maximum day demand upon the system in addition to a dual fire flow requirement of 4,000 gpm in East Boston and a fire flow requirement of 3,500 gpm in Winthrop. For this worst case condition, the Hydraulic Grade Line at Meter 41 dropped to 158 BCBD. (It should be noted that this HGL is based upon assumed friction factors for the NHDS system and proposed upstream, shafts 9 and 9A, improvements.)

Within Winthrop's system the HGL is maintained at a value less than the HGL available from the NHDS. The Town requires that the MWRA control the HGL by means of pressure regulators at Meter 41. Winthrop's system is designed to operate with the MWRA regulators set at 75 psi (el. 203 BCBD). The Town, however, has limited pressure at the regulators to as low as 60 to 65 psi (168 to 180 BCBD) to reduce the rate of leakage from some of the Town's older pipes. The Town has been steadily upgrading sections of problem pipe and intends to ultimately utilize the available pressure.

At present, the Town's average-day demand is approximately 2 mgd. The Town is nearly 100 percent developed, and the Town's future water needs are expected to increase slowly, by no more than 10 percent. The ratio of average-day demand to maximum day demands of 1.75, which is typical for communities similar to Winthrop, was used for this evaluation. The fire flow required for Winthrop has been estimated as 3,500 gpm as given in the earlier MDC reports, and was used for this evaluation.

The administration of the existing water supply facilities on Deer Island involve the Boston Public Facilities Department, the Winthrop Water Commissioners, the Winthrop Selectmen's office, and the MWRA. Deer Island's water is provided by a connection from the Winthrop distribution system. The MWRA's treatment plant and the Suffolk County House of Correction are customers of the Winthrop Water Department.

Several water mains have been extended from Winthrop to Deer Island over the years. Both a 6-inch and a 12-inch City of Boston water main were installed in the 1800s across Shirley Gut before the gut was filled. The 12-inch line is known to be broken and the valve to it is closed. The pipe is not, however, capped and sealed. The status of the 6-inch line is unknown. There are also two 8-inch mains to the island. One provides potable water to the Deer Island House of Correction, and one provides potable water to the existing treatment plant. All of these various lines are interconnected.

Fire flow tests performed in late November of 1986 by the Boston Water and Sewer Commission showed the following results:

- |    |  |                   |
|----|--|-------------------|
| a. | 8-inch main at piggery                           | 450 gpm at 20 psi |
| b. | Unknown size main at gate<br>east of guard booth | 750 gpm at 20 psi |

Universal Engineering has conducted an examination of the water system on Deer Island on behalf of the City of Boston to assess its capacity as part of safety improvements for the House of Correction.

## 5.0 AVAILABLE STORAGE

There is no potable water storage at present on Deer Island. In Winthrop, storage is provided by an uncovered standpipe located on top of Cottage Hill, near Point Shirley. The standpipe is 100 ft high and 40 ft in diameter and has a theoretical capacity of 0.94 million gallons. The tank's overflow elevation is 205.65 BCBD, but because of the pressure reduction at Meter 41, the Town can not fully utilize the tank, and the usable storage is inadequate to meet the peak hourly fluctuations during times of maximum daily demands. The available storage in the Winthrop system is inadequate for the Town's needs and, as such, offers no reserve capacity to the plant site.

The existing and future conditions with regard to water needs in Winthrop and Deer Island are summarized below:

Present and Projected Water Consumption in mgd

	<u>1987</u>	<u>2000</u>
<u>Average Daily Consumption</u>		
Winthrop	2.0	2.2
Deer Island	<u>0.1</u>	<u>1.0</u>
Total	2.1	3.2

Maximum Daily Consumption

Winthrop	3.5	3.4
Deer Island	<u>.2</u>	<u>2.0</u>
Total	3.7	5.4

Required Fire Flow

Winthrop	5.04 (3,500 gpm)	5.04 (3,500 gpm)
Deer Island	N/A	4.32 (3,000 gpm)

## 6.0 SUPPLY ALTERNATIVES

### 6.1 ALTERNATIVES ASSOCIATED WITH REVERE/WINTHROP METER 41

The new plant's maximum daily potable water needs of 2.0 mgd cannot be supplied through Winthrop's system and/or through the present connections. There is an adequate supply of water available upstream of Meter 41 and alternatives for transmitting the required water from Meter 41 to the plant site have been investigated. In developing and analyzing alternatives, primary consideration was given to ensuring that the plant's supply be reliable and that it not negatively impact the Town's pressure and/or supply. Each alternative's benefits to Winthrop have also been considered.

There are three alternatives to supply water to the secondary treatment facility from the vicinity of Meter 41.

The first alternative is to construct a water main dedicated to the plant's needs from upstream of the MWRA Meter 41 through Winthrop to the plant site. This water main would be sized to provide a reliable supply to the secondary treatment facility. A dedicated main would utilize



the HGL available upstream of Meter 41. This water main would be controlled by MWRA, and the maintenance of the main would be MWRA's responsibility. A dedicated main would remove the present demands of the island from the Town system. With a single pipeline, however, a break anywhere along the main would cause a disruption of supply to the treatment facility.

The second option is to improve sections of the Town of Winthrop's water system and pass water from Meter 41 through Winthrop's system to the plant site. Under this option, the plant's water supply would be dependent on the condition of Winthrop's system and upon pressures available in the Winthrop system, instead of pressures upstream of Meter 41. In the event of a high water demand at the plant, lower pressures in Winthrop's water system could be experienced. The Town would have responsibility for this system's maintenance.

The third alternative is to construct a dedicated water main and to tie the dedicated main into Winthrop's water system. The advantages of this alternative are that there would be two potential sources to provide water for both the Town and the Plant. The dedicated water main would be controlled and maintained by the MWRA. Metered connections between the dedicated main and the Town could provide backup for both Town and plant emergencies and provide water to the Town during peak demand periods.

The proposed route through Winthrop for all three alternatives is shown on Figure I-1.

## 6.2 ANALYSIS OF ALTERNATIVES ASSOCIATED WITH REVERE/WINTHROP METER 41

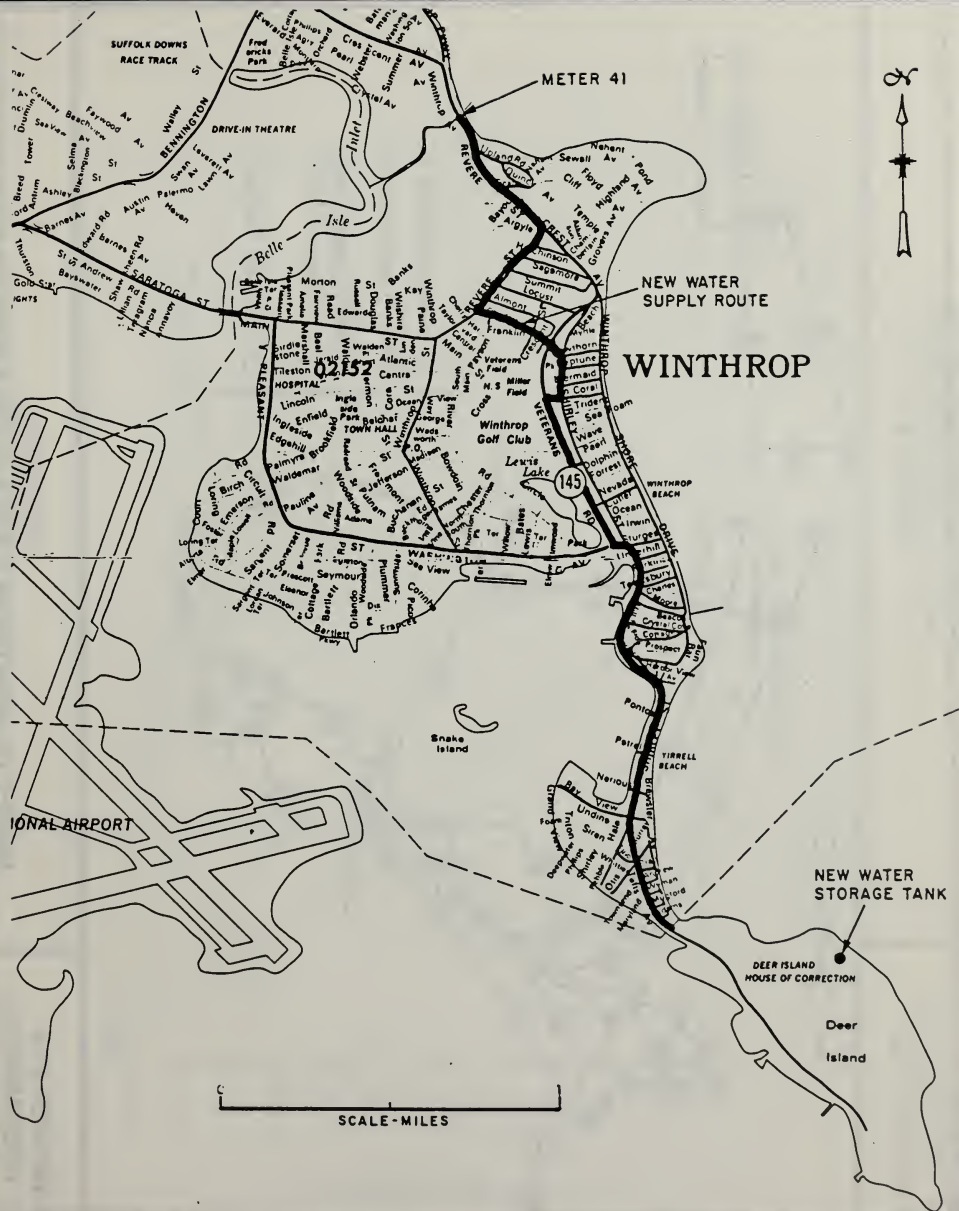
To analyze the alternatives for the supply of water to the treatment plant and their potential impacts, a hydraulic model of the Town of Winthrop's water supply system was prepared. It covered the area from MWRA Meter 41 to Point Shirley in Winthrop. While Winthrop's system consists of ductile and cast iron pipes varying in size from 6 to 20 inches in diameter, the hydraulic model included only the major pipes in the Town's system. Along the route from Meter 41 to Deer Island, the water mains consist mostly of 16-inch, 12-inch, and 10-inch diameter pipes. For continuity, a few 8-inch pipes were included in the model. The schematic of the hydraulic model is shown in Figure I-2.

The model was examined under various simulated flow conditions. Within the model, conservative friction factors and ground elevations were selected, and a maximum available hydraulic grade line (HGL) elevation of 195.75 BCBD was assumed at MWRA Meter 41. This HGL is slightly less than the available HGL of 200 BCBD under peak flow conditions and is assumed to reflect the impact of the plant's demands on the NHSD.

The model was utilized to determine the required diameter of a 14,400-ft-long dedicated water main. The analysis compared 16-inch and 20-inch diameter ductile iron water mains at various flow conditions. The results are depicted graphically in Figures I-3 and I-4, and are tabulated in Table I-2.

In assessing the results, a minimum pressure at all buildings of 30 psi under maximum day demands has been established as a criterion at the plant site. The equivalent HGL for the





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FIGURE I-1  
PROPOSED ROUTING OF POTABLE  
WATER SERVICE



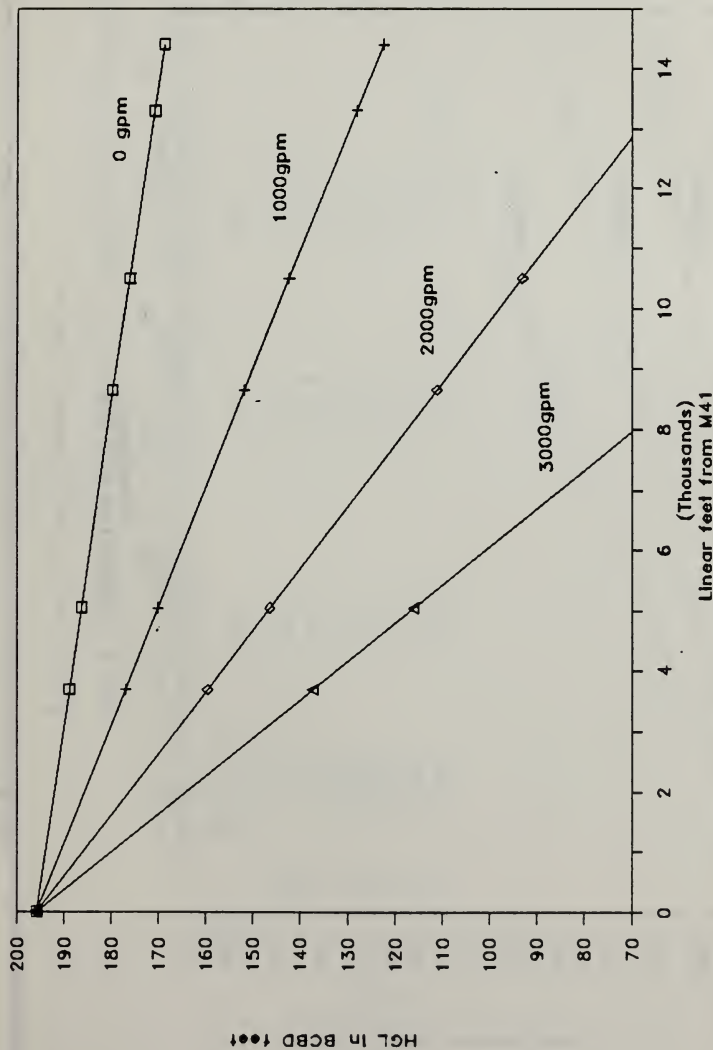


FIGURE I-3  
HGL OF MWRA 16IN MAIN  
(ADF OF 2.0MGD PLUS FF)

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AUTHORITY

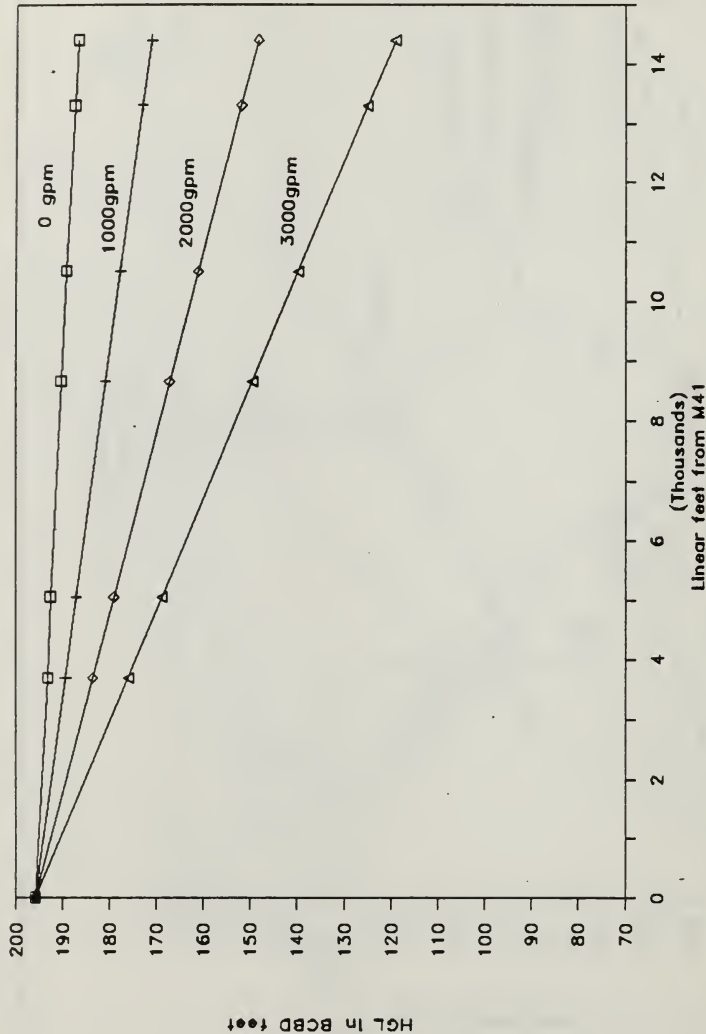


FIGURE I-4  
HGL OF MWRA 20IN MAIN  
(ADF OF 2.0MGD PLUS FF)

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## CHGL OF DEDICATED MAINS FOR VARIOUS FLOW CONDITIONS

### Dedicated 16-Inch Diameter Main

I-11

TABLE I-2

## HGL OF DEDICATED MAINS FOR VARIOUS FLOW CONDITIONS

Dedicated 20-Inch Diameter Main  
(continued)

		HGL @41=195.75				HGL @41=195.75				HGL @41=195.75			
<u>Location</u>	Mode <u>No.</u>	<u>Distance From Meter 41 in feet</u>	<u>ADF = 2.0MGD</u>		<u>HGL</u>	<u>ADF = 2.0MGD</u>		<u>HGL</u>	<u>ADF = 2.0MGD</u>	<u>ADF = 2.0MGD</u>		<u>ADF = 2.0MGD</u>	
			<u>FF = 0 gpm</u>			<u>FF = 1000 gpm</u>			<u>FF = 2000 gpm</u>			<u>FF = 3000 gpm</u>	
Meter 41	100	0	195.8		195.8	195.8		195.8	195.8		195.8	195.8	
Beverly/Shrly	2	3700	193.0		189.4	189.4		183.5	183.5		176.0	176.0	
Shrly/Beach	8	5050	192.6		187.1	187.1		179.1	179.1		168.8	168.8	
Shrly/Sturgis	19	8650	190.3		180.9	180.9		167.2	167.2		149.6	149.6	
Shrly/Terr/Prsp	22	10500	189.1		177.7	177.7		161.1	161.1		139.8	139.8	
Taft/Adams	23	13300	187.3		172.9	172.9		151.9	151.9		124.9	124.9	
Site	230	14400	186.6		171.0	171.0		148.2	148.2		119.0	119.0	



highest building would be 120 ft. Either a 16-inch or a 20-inch main can supply water to the site under maximum day demands at an HGL above 120. The 16-inch main has the capacity to deliver a fire flow of up to 1,000 gpm plus maximum day demands (this is equivalent to a rate of 3.44 mgd). The 20-inch main has the capacity to convey up to 3,000 gpm plus maximum day demands (this is equivalent to a rate of 6.32 mgd). It is unknown at this time what the impact would be on pressure at Meter 41 from a fire flow of 3,000 gpm, but it is reasonable to assume that the pressure would drop below the set point of HGL 190 for Winthrop's pressure regulator.

For a dedicated main, it is recommended that on-site storage be provided to dampen the impact of diurnal demands and to provide a supply in the event of a break in the dedicated main. The on-site storage should be equal to the estimated fire flow volume of 0.54 mg plus 50 percent of the maximum day demand, or 1.0 mg, to provide for diurnal variations in demand. The volume of on-site storage should be, as a minimum, 1.5 mg, and to be usable it should all be stored above elevation 120. The tank would be on-line storage, and an altitude valve would regulate the inflow of water to the tank, and the plant would draw their water from the tank.

For the alternative that involved the Town's system, the model was used initially to analyze the HGL for existing conditions across the Town during periods of maximum demand as well as during fire flows, but without the new plant's demands. With the Town of Winthrop's water tank on line, and using an HGL elevation of 190.00 (downstream of Meter 41), the Town's tank will stabilize at elevation 170, which is 35 feet below its overflow. For a fire flow condition of 1,000 gpm, the HGL drops rapidly and the stabilized HGL is below elevation 100. Portions of Winthrop have dwellings constructed above elevation 100 and these areas would receive inadequate pressure under these conditions. These HGLs are shown in Figure I-5 and are tabulated in Table I-3.

The Town's system was then modeled with the new plant's flows included and with the assumption that the system would be upgraded by the installation of larger pipes. The system was analyzed based on the assumption that a 20-inch pipe would be constructed from the existing 20-inch pipe at Shirley Avenue and Sturgis Street to the plant site. This improved system was analyzed assuming maximum day demand plus a 2.0 mgd flow to the plant site. It was further assumed that the existing 20-inch line was opened back to Meter 41 and that the HGL downstream of Meter 41 was 190 ft. For this condition, the HGL is approximately equivalent to the present maximum day HGL, and is depicted in Figure I-5 and tabulated in Table I-3. For this alternative, as for the dedicated main alternatives, on-site storage is provided. For this alternative, a simultaneous 3,000 gpm fire flow plus maximum day demands results in a 70 foot drop in the HGL across the Town, to HGL 120, below the elevation of several homes. The impact upon the HGL in the NHDS has not been calculated but is assumed to drop below the set point of 190 HGL at Meter 41.

For the third alternative, to construct a dedicated main and tie it into Winthrop's system to provide redundancy as well as to supplement pressures, the HGLs of the first two alternatives have been graphed together and are shown in Figure I-5 and Table I-3. Under maximum day demand, the dedicated main acts as a supplement to Winthrop's system. This is primarily true because the dedicated main utilizes the available HGL from upstream of Meter 41. The on-site storage could also be available to the Town for peak hourly needs and particularly for the fire

TABLE I - 3

## HGL OF WATER SUPPLY ALTERNATIVES

Location	No.	Distance from Mode Meter 41 in feet	Max day Present system HGL @41=19	Max Day Present system HGL @41=190 plus a FF of 1000 gpm at Mode 19	Max Day HCL @41=190 plus a 2mgd at plant via a 20 in from mode 2 to 23	Dedicated 16 in main HGL @41=195.75	Dedicated 20 in main HGL @41=195.75
			<u>HGL</u>	<u>HGL</u>	<u>HGL</u>	<u>HGL</u>	<u>HGL</u>
Meter 41	100	0	190.0	190.0	190.0	195.7	195.8
Bevr/Shrly	2	3700	187.0	180.3	181.2	188.8	193.0
Shrly/Beach	8	5050	183.8	167.9	173.2	186.3	192.6
Shrly/Sturgis	19	8650	169.8	98.8	171.7	179.5	190.3
Shrly/Terr/Prsp	22	10500	169.7	98.8	171.7	176.1	189.1
Taft/Adams	23	13300	168.3	97.3	172.0	170.8	187.3
Site	230	14400				168.8	186.6

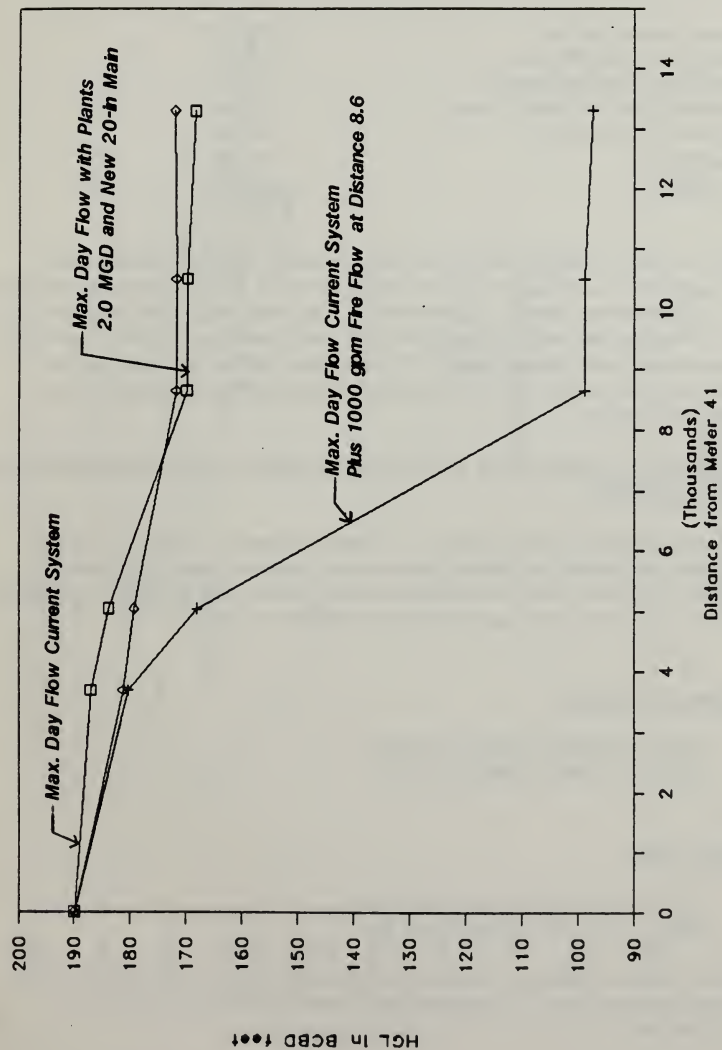


FIGURE I-5  
HGL FOR MAX DAY DEMANDS  
(TOWN'S SYSTEM)

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flow needs.

The cost of the third alternative discussed above has been estimated as follows:

Elevated storage reservoir	\$2,336,000
Supply line through Winthrop	1,509,000
Supply lines on MWRA property	334,000
Distribution lines on MWRA property	177,000
Distribution lines in plant	388,000
Miscellaneous	135,000
Pump station	205,000
	<u>\$5,084,000</u>

The MWRA can satisfy its needs from a 16-inch dedicated main. A 20-inch dedicated main provides a higher HGL under maximum flow conditions and would be of greater benefit to Winthrop as a means of supplementing pressure. The elevation of the on-site storage would be lower than the Town's present tank and would not supplement peak hourly demand in the Town; that would be done by the dedicated main's interconnection. The on-site tank could provide additional fire protection to the Town; the extent of the fire protection would depend upon the final size and elevation of the on-site tank.

### 6.3 ALTERNATIVES ASSOCIATED WITH CHELSEA CREEK METER 64 OR MERIDIAN STREET BRIDGE METER 3

An alternative which does not entail disruption of Winthrop's streets is to construct a 24-in. main from either the Chelsea Creek Bridge Meter 64 or the Meridian Street Bridge Meter 3, around Logan Airport using a water route through Winthrop Harbor onto Deer Island. Hydraulic analysis of this alternative indicates that the following conditions will prevail:

#### At Meter 3 or Meter 64:

HGL = 140 BCD at average daily flow

HGL = 115 BCD at peak hourly flow

#### At Deer Island:

HGL = 126.3 BCD at average daily flow

HGL = 101.3 BCD at peak hourly flow

The MWRA is currently completing cleaning and lining of one of the two 48-inch mains which supply water to the Meter 3 area. A potentially feasible water routing of this alternative is shown on Figure I-6.

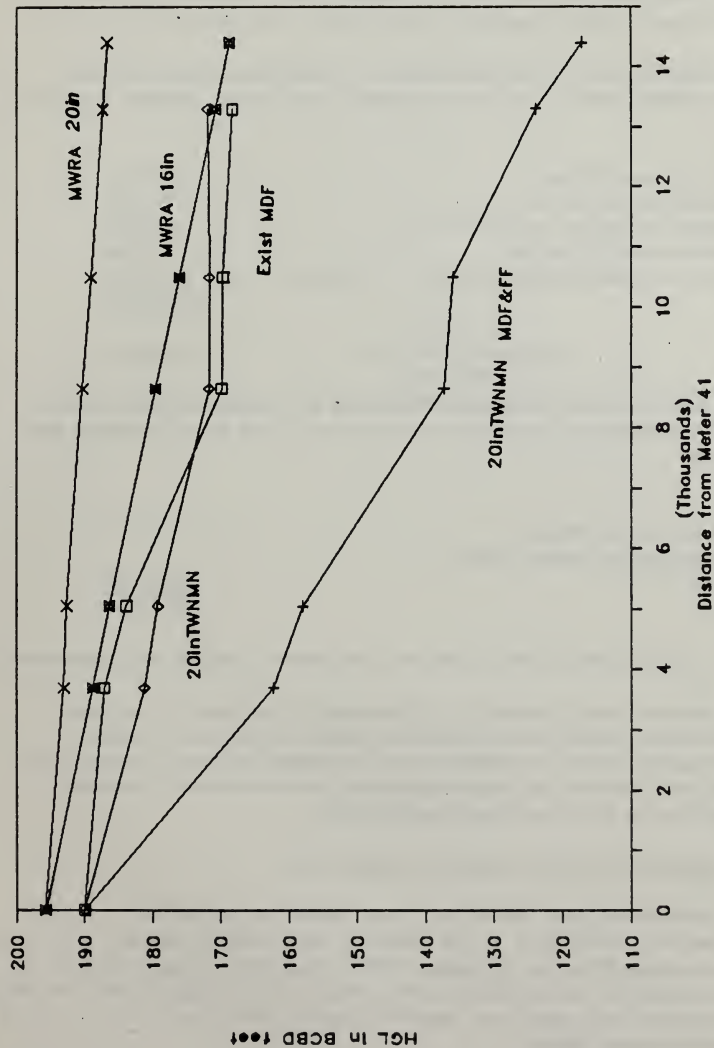


FIGURE I-6  
HGL FOR MAX DAY DEMANDS  
(HGL OF ALTERNATIVES)

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The subaqueous portion of the pipeline would be constructed of 24,000 ft of 24-inch-diameter bell and spigot filament-wound vinyl ester pipe in a dredged 6-ft-deep trench backfilled with 3/4-inch crushed stone and topped with 6-inch cobble stones for protection from mechanical damage and scour. Total dredged volume would be approximately 80,000 yd<sup>3</sup>.

The total installed cost for the subaqueous portion of the installation, based on a vendor supplied telephone estimate from Fibercast Company of Sand Springs, Oklahoma, is as follows:

24 inch pipe at \$90 per ft	= \$2,160,000
Dredging at \$28 per yd <sup>3</sup>	= 2,400,000
Backfill crushed stone at \$7.90 per ton	= 836,000
Armor stone at \$20 per ton	= 319,000
Other construction activities	= <u>1,200,000</u>
	\$6,915,000

approximately, therefore: \$7,000,000

The total installed cost based on the use of pipe capable of 15-degree deflection at each joint and suitable for subaqueous installation in soft bottom muds, along the route described above, is as follows:

24-inch pipe at \$383 per ft	= \$ 9,200,000
All construction activities at \$600 per ft <sup>(1)</sup>	= <u>14,400,000</u>
	\$23,600,000

<sup>(1)</sup> Empirical data for difficult subaqueous environments, S&W Estimating Department.

The two estimated prices in paragraph 6.3 differ primarily in the degree of conservatism employed and can, therefore, be said to define the range of probable costs. Although additional engineering would be required to refine the estimated cost for this alternative, the range of costs is such that it can be concluded that this alternative would be considerably more expensive than the overland route through Winthrop.

#### 6.4 ANALYSIS OF THE EAST BOSTON ALTERNATIVE

Potential difficulties associated with the East Boston alternative include possible encroachment on a wetland north of Logan Airport, the need to obtain a dredging permit for the subaqueous portions of the route, disruption of traffic in East Boston during construction, the need to cross Route 1A and the Blue Line subway tracks northwest of Logan Airport, the crossing of a potential third harbor tunnel route, and the environmental impacts and expenses associated with excess dredge spoil disposal.



Secondary Treatment Facilities Plan

Volume III

Appendix I  
Water Supply

The procedure to perform construction within the vicinity of Logan Airport is to first have the project submit a request for permission to construct.

This request would then be reviewed by Massport and appropriate conditions attached. (This procedure is similar to the procedure an airport tenant, such as an airline, would follow.)

Massport and the Federal Aviation Administration (FAA) have established that runways are theoretically 1000-ft-wide with a 7:1 slope upwards from 500 ft off the centerline of the runway.

Within the airport there is a perimeter road, off the edge of the runway. This roadway is typically about 500 ft off centerline and would have to be kept open continuously. Construction equipment could not park on this roadway or construct within it. This would require that construction be outside of the roadway on the water side within the riprap or tide water areas.

During periods of poor visibility, no vehicles of any sort are allowed in the runway area or in the perimeter road area. All construction would have to cease.

Massport standard conditions restrict access to runways and adjacent areas. At the end of a runway, extra special provisions would be required, which would likely require some night work when planes are not flying.

It is unclear whether Massport regulations and review would require that a water main would have to be installed within a sleeve. As a minimum, sleeves are likely to be required at end of runways.

## 7.0 CONCLUSIONS REGARDING VARIOUS ALTERNATIVES

The apparent environmental and social impacts of the East Boston alternative, combined with its high price, make the Winthrop alternative more attractive.

Of the three Winthrop alternatives, the dedicated main, tied into Winthrop's existing distribution system, is considered the most attractive for the following reasons:

- o It provides redundancy to both Deer Island and the Town of Winthrop.
- o It is capable of supplementing pressure in Winthrop's distribution system should the need arise.

## Appendix J



**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix J  
Design Criteria**

APPENDIX J

SUMMARY OF RECOMMENDED PLAN  
UNIT PROCESS SIZING

Table J-1 has been constructed to offer a quick reference to the sizing and equipment requirements of each recommended unit process and the design criteria used in sizing units and equipment. A summary of the equipment at the remote headworks is also included in the table. Odor/VOC control equipment and ancillary facilities appear in the table as well. For a more concise description of the units, the equipment, the flow scheme and interprocess conveyance refer to Section 11.0.



TABLE J-1

DEER ISLAND SECONDARY TREATMENT FACILITY  
SUMMARY OF RECOMMENDED PLAN  
UNIT PROCESS SIZING AND EQUIPMENT

## I. REMOTE HEADWORKS

## A. CHELSEA CREEK

## 1. MECHANICALLY CLEANED CLIMBER SCREENS

Number of Screens (includes 1 standby unit)	4
Bar Spacing	3/4 in
Screen Dimensions:	
Width	12 ft
Sidewater Depth (maximum)	6 ft 10 in

## 2. GRIT COLLECTION

Number of Channels (includes 1 standby unit)	4
Channel Dimensions:	
Width	24 ft 6 in
Length	88 ft
Sidewater Depth (maximum)	11 ft 4 in
Capacity, each	117 mgd

## B. COLUMBUS PARK

## 1. MECHANICALLY CLEANED CLIMBER SCREENS

Number of Screens (includes 1 standby unit)	4
Bar Spacing	3/4 in
Screen Dimensions:	
Width	10 ft 6 in
Sidewater Depth (maximum)	6 ft

## 2. GRIT COLLECTION

Number of Channels (includes 1 standby unit)	4
Channel Dimensions:	
Width	20 ft
Length	58 ft 4 in
Sidewater Depth (maximum)	9 ft 8 in
Capacity, each	61 mgd

C. WARD STREET

1. MECHANICALLY CLEANED CLIMBER SCREENS

Number of Screens (includes 1 standby unit)	4
Bar Spacing	3/4 in
Screen Dimension:	
Width	10 ft 6 in
Sidewater Depth (maximum)	6 ft 6 in

2. GRIT COLLECTION

Number of Channels (includes 1 standby unit)	4
Channel Dimensions:	
Width	20 ft
Length	80 ft
Sidewater Depth (maximum)	10 ft 1 in
Capacity, each	85.3 mgd

D. WINTHROP TERMINAL

Number of Climber Screens (includes 1 standby unit)	3
Bar Spacing	7/8 in
Screen Dimension:	
Width	4 ft
Sidewater Depth (maximum)	10 ft 6 in
Capacity, each	62.5 mgd
Number of Pumps (includes 2 standby units)	6
Pump Capacity, each	32 mgd
Motor Horsepower	600 hp

II. NUT ISLAND - PRELIMINARY TREATMENT

A. CLIMBER SCREENS

Number of Units (includes 2 standby unit)	4
Bar Spacing	3/4 in
Channel Dimensions:	
Width	11.5 ft
Depth (maximum)	11.5 ft
Capacity, each	180 mgd
Velocity through Screen (maximum)	3 fps

B. CENTRIFUGAL GRIT CHAMBER

Number of Units (includes 1 standby unit)	6
---	---

Diameter	24 ft
Capacity, each	72 mgd
Total Number of Grit Slurry Pumps (includes 6 standby units)	12
Type of Pump	Vortex
Capacity, each	150 gpm
Horsepower	5 hp
Number of Cyclone Grit Concentrators (includes 2 standby units)	5
Size	12 in. dia.
Capacity, each	150 gpm
Number of Grit Washers (includes 2 standby unit)	5
Screw Size	12 in.

### III. DEER ISLAND

#### A. PRELIMINARY TREATMENT

Number of Batteries	2
Number of Centrifugal Grit Chambers per battery (includes 1 standby unit per battery)	8
Diameter	24 ft
Capacity, each	74 mgd
Total Number of Grit Slurry Pumps	32
Number of Standby Pumps	16
Type of Pump	Vortex
Capacity, each	150 gpm
Horsepower	5 hp
Number of Cyclone Grit Concentrators (includes 4 standby units)	10
Size	12 in. dia.
Capacity, each	150 gpm
Number of Grit Washers (includes 3 standby units)	10
Screw size	12 in. dia.

#### B. PRIMARY TREATMENT

##### 1. STACKED RECTANGULAR PRIMARY CLARIFIERS

Number of Batteries	4
Total Number of Stacked Sets per Battery	24
Number of Stacked Sets Required at Peak Flow	21
Number of Standby Stacked Sets	3
Tank Dimension:	
Effective Length:	Upper 181 ft

	Lower	191 ft
	Width (upper and lower)	20.5 ft
	Sidewater Depth (minimum, upper and lower)	12.0 ft
	Surface Area per Stacked Set	7.626 sf
Overflow Rate (not including standby tankage)		
	Peak Flow	2000 gpd/sf
	Flow Receiving Only Primary Treatment	1200 gpd/sf

## 2. AERATED INFLUENT CHANNEL

Number per Battery	1
Channel Dimensions:	
Length	530 ft
Width	6 ft
Depth	18
Aeration Rate	3 scfm/1f
Number of Blowers per Battery	
(includes 1 standby unit)	2
Capacity, each	1600 scfm
Horsepower	100 hp

## 3. NON METALLIC CHAIN AND FLIGHT SLUDGE COLLECTORS

Number of Drives (one drive per two adjacent tanks)	96
Horsepower, per drive	0.5 hp

## 4. SLUDGE PUMPS

Total Number of Pumps	80
Number of Standby Pumps	32
Capacity, each	120 gpm
Horsepower	7.5 hp

## 5. SCUM PUMPS

Total Number of Pumps	8
Number of Standby Pumps	4
Capacity, each	900 gpm
Horsepower	40 hp

## 6. TRAVELING SCREENS FOR PORTION OF FLOW RECEIVING ONLY PRIMARY TREATMENT

Design Flow	190 mgd
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Screen Bay	15 ft by 15 ft
Screens	
Number of Screens (includes 1 standby unit)	3
Type of Screen	Dual Flow
Width (nominal)	6 ft
Screen Mesh	1/4 in
Head Loss	< 1 ft
Velocity through Screen (maximum)	2 fps
Motor Horsepower	3 hp

Spray Water Pumps	
Number of Pumps (includes 1 standby unit)	2
Capacity, each	350 gpm
tdh	25 ft
Refuse Pumps	
Number of Pumps (includes 1 standby unit)	2
Capacity, each	350 gpm
tdh	25 ft

## C. SECONDARY TREATMENT

### 1. ANAEROBIC SELECTOR BASINS

Number of Batteries	4
Number of Compartments Per Battery	4
Compartment Dimension:	
Length	64 ft
Width	90 ft
Sidewater Depth	18 ft
Freeboard	3 ft
Volume per Battery	3.1 mil gal
Hydraulic Retention Time (average high groundwater flow including average RAS)	20 min
Mixing Requirements	0.4 hp/1000 cf
Total Number of Mechanical Mixers	
(2 mixers per compartment)	32
Mixer Size	20 hp

### 2. AERATED INFLUENT CHANNEL

Number of Channels per Battery	1
Dimensions	
Length	128 ft
Width	14 ft
Sidewater Depth	14 ft

Aeration Rate	3 scfm/lf
Number of Blowers per battery (includes 1 standby unit)	2
Capacity, each	500 scfm
Horsepower	20 hp

### 3. AERATION BASINS

Number of Batteries	4
Number of Trains Per Battery	3
Number of Stages Per Train	4
Stage Dimension:	
Length	70 ft
Width	70 ft
Sidewater Depth	23.5 ft
Freeboard	5 ft
Volume per Battery	10.34 mil gal
Total Volume	41.34 mil gal
Total Number of Surface Aerators (with draft tubes)	48
Horsepower    Stage 1	150 hp
Stage 2	100 hp
Stage 3	100 hp
Stage 4	100 hp
Hydraulic Retention Time (average high groundwater flow)	1.48 hr
F/M (based on $BOD_r$ and MLVSS)	0.73 days <sup>-1</sup>
SRT	2.3 days
MLSS	2000 mg/l
MLVSS	1600 mg/l
Oxygen Required per lb BOD removed	0.85 lb
Number of Purge Blowers per Battery (includes 1 standby unit)	2
Capacity	10,000 scfm
Motor Horsepower	50 hp

### 4. CRYOGENIC OXYGEN GENERATION WITH MOLECULAR SIEVE PREPURIFIER

Number of Units (1 in operation at any one time)	2
Capacity	300 tpd
Number of Compressors (each size with 1 standby unit)	4
2-100 percent capacity	3500 hp
2-70 percent capacity	2500 hp



LOX Storage	1000 tons
Number of Cooling Water Pumps	
(includes 2 pumps per system each with	
1 standby unit)	4
Capacity, each	1200 gpm
Horsepower	15 hp

## 5. STACKED RECTANGULAR SECONDARY CLARIFIERS

Number of Batteries	4
Total Number of Stacked Sets Per Battery	36
Number Stacked Sets Required at Peak Flow	32
Number of Standby Stacked Sets	4
Tank Dimension:	
Effective Length: Upper	160 ft
Lower	180 ft
Width (upper and lower)	20.5 ft
Sidewater Depth (minimum, upper and lower)	13 ft
Surface Area per Stacked Set	6970 sf
Overflow Rate (high groundwater average daily flow)	750 gpd/sf
(not including standby tankage)	

Aerated Influent Channel	
Length	420 ft
Width	6 ft
Depth	18 ft
Aeration Rate	3 scfm/1f
Number of Blowers per battery	
(includes 1 standby unit)	2
Capacity, each	2600 scfm
Horsepower	150 hp

Non Metallic Chain and Flight Sludge Collectors	
Number of Drives (one drive per two	144
adjacent tanks)	
Horsepower	0.5 hp

RAS Pumps	
Total Number of Pumps	20
Number of Standby Pumps	8
Capacity	30,000 gpm
Horsepower	300 hp

WAS Pumps	
Total Number of Pumps	20
Number of Standby Pumps	8

Capacity	500 gpm
Horsepower	7.5 hp

Scum Pumps	
Total Number of Pumps	16
Number of Standby Pumps	8
Capacity	700 gpm
Horsepower	40 hp

#### D. DISINFECTION - PURCHASED SODIUM HYPOCHLORITE

Number of Tanks	4
Number of Passes Per Tank	3
Pass Dimensions:	
Length	310 ft
Width	20 ft
Depth (peak flow)	24 ft
Total Volume	13.36 mg
Detention Time (peak flow)	15 min
Number of Storage Tanks	3
Capacity, each	250,000 gal
Storage Tank Dimension:	
Diameter	40 ft
Height	27 ft
Number of Metering Pumps	
(includes 3 standby unit with primary treatment)	13
Capacity	572 gal/hr
Number of Sodium Metabisulfide Pumps	
(includes 4 standby units)	18
Capacity	572 gal/hr

#### IV. ODOR/VOC CONTROL SYSTEM

##### A. NUT ISLAND

Air Flow	55,000 cfm
Number of Scrubbers	4
Diameter of Scrubbers	7 ft
Number of Fans	4
Fan Size	27,500 cfm
Motor Horsepower	125 hp
Number of Dual Bed Carbon Adsorbers	6
Bed Diameter	12 ft

Equipment Redundancy	100 percent
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B. WINTHROP TERMINAL PUMP STATION

Air Flow	15,300 cfm
Number of Scrubbers	2
Diameter of Scrubbers	6 ft
Number of Fans	2
Fan Size	15,300 cfm
Motor Horsepower	75 hp
Numbers of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	50' x 80' x 28'

C. SCREENING FACILITY

Air Flow	21,000 cfm
Number of Scrubbers	2
Diameter of Scrubbers	7 ft
Number of Fans	2
Fan Size	21,000 cfm
Motor Horsepower	100 hp
Number of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	75' x 60' x 28'

D. PRELIMINARY AND PRIMARY TREATMENT

Two facilities are required. Each facility serves two batteries of grit chambers, primary clarifiers, influent channels, and maintenance exhaust. The West facility also serves grit classifier, South System pump station and the primary splitter box.

East Facility

Air Flow	
Grit Chambers	19,000 cfm
Primary Clarifier/Influent Channel	32,600 cfm
Maintenance Exhaust	22,100 cfm

Scrubbers

Grit Chambers	2 - 6 ft dia.
Primary Clarifier/Influent Channel	2 - 9 ft dia.
Maintenance Exhaust	1 - 7 ft dia.

#### Fans

Grit Chambers	2 @ 19,000 cfm 100 hp each
Primary Clarifiers/Influent Channel	2 @ 32,600 cfm

Maintenance Exhaust	150 hp each 1 @ 22,100 100 hp
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#### Carbon Adsorbers - Dual Bed

Grit Chamber	2 - 12 ft dia.
Primary Clarifiers/Influent Channels	4 - 12 ft dia.
Maintenance Exhaust	1 - 12 ft dia.

#### Building Dimensions

80' x 125' x 30'

#### West Facility

##### Air Flow

Grit Chamber	19,000 cfm
Primary Clarifier/Influent Channel	39,800 cfm
Grit Classifiers and Primary Maintenance	21,000 cfm

##### Scrubbers

Grit Chamber	2 - 6 ft dia
Primary Clarifier/Influent Channel	2 - 9 ft dia
Grit Classifiers and Primary Maintenance	3 - 7 ft dia

#### Fans

Grit Chamber	2 @ 19,000 cfm 100 hp each
Primary Clarifier/Influent Channel	2 @ 39,800 cfm 200 hp
Grit Classifiers and Primary Maintenance	3 @ 21,000 100 hp

#### Carbon Adsorbers - Dual Bed

Grit Chamber	2 - 12 ft dia.
Primary Clarifier/Influent Channel	4 - 12 ft dia.
Grit Classifiers and Primary Maintenance	3 - 12 ft dia.

#### Building Dimensions

85' x 150' x 30'

#### E. Secondary Treatment

Two facilities are required. Each facility serves two batteries of selector zones, oxygen basins and influent and effluent channels. The North facility also serves the secondary splitter box.

## South Facility

Air Flow	18,000 cfm
Number of Scrubbers	2
Diameter of Scrubbers	5 ft
Number of Fans per Facility	2
Fan Size	18,000 cfm
Motor Horsepower	75 hp
Number of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	50' x 80' x 28'

## North Facility

Air Flow	21,000 cfm
Number of Scrubbers	2
Diameter of Scrubbers	7 ft
Number of Fans	2
Fan Size	21,000 cfm
Motor Horsepower	100 hp
Number of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	50' x 80' x 28'

## V. ANCILLARY FACILITIES

### A. PLANT WATER

Required Average Flow	45 mgd
Number of Pumps (includes 2 standby units)	5
Pump Capacity @ 100 tdh	15 mgd





## Appendix L



**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix L  
Flows & Loads**

## APPENDIX L

### FLOWS AND LOADS

A breakdown of the flows by headworks for the North System -- Chelsea Creek, Columbus Park, Ward Street, and Winthrop Terminal -- and the South System flows from Nut Island, are presented in the following Tables L-1 through L-10. Flows are given in ten-year increments from 1990 to the design year 2020 for both low and high groundwater conditions. Average day wastewater flows are broken down into domestic flows and major and minor non-domestic flows. Minimum day, maximum day, and peak hour wastewater flows were calculated by applying appropriate peaking factors to the average flow. To these wastewater flows, average and maximum infiltration/inflow were added. Total flow with storm was taken to be the capacity of each of the headworks for maximum day and peak hour flow.

Annual average biochemical oxygen demand (BOD) and total suspended solids (TSS) loadings have also been segregated by North and South systems based on the 1986 Fall sampling program, and are presented in Tables L-11 through L-13. Data for 1986 and from 1990 to 2020 in ten-year increments are given. Maximum day, maximum 15-day, and maximum 30-day loadings shown were calculated using appropriate peaking factors.

Storm loadings were obtained by assuming an additional 165,000 lbs/day BOD loading and 400,000 lbs/day TSS loading attributed to the storm flow.

For more information on flows and loadings refer to Section 6.0 of this Volume and Section 8.0 of Volume II, Facilities Planning Background.

TABLE L-1

FLOWS AT CHELSEA CREEK HEADWORKS  
LOW GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		37				39				38		
NON DOMESTIC												
MAJOR USERS		10				10				10		
MINOR USERS		10				11				14		
SUBTOTAL	39	57	83	119	41	60	85	125	41	60	85	125
INFILTRATION AND INFLOW	57	57	71	71	57	57	71	71	57	57	71	71
TOTAL	96	114	154	190	98	117	156	196	98	117	156	196
TOTAL WITH STORM FLOW			350	350			350	350			350	350

Note: 350 mgd maximum capacity

TABLE L-2

FLOWS AT CHELSEA CREEK HEADWORKS  
HIGH GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		37				39				38		
NON DOMESTIC										39		
MAJOR USERS		10				10				10		
MINOR USERS		10				11				14		
SUBTOTAL	39	57	83	119	41	60	85	125	41	60	85	125
INFILTRATION AND INFLOW	129	129	176	176	129	129	176	176	129	129	176	176
TOTAL	168	186	258	295	170	189	261	300	170	189	261	300
TOTAL WITH STORM FLOW			350	350			350	350			350	350

Note: 350 mgd maximum capacity



TABLE L-3

FLOWS AT COLUMBUS PARK HEADWORKS  
LOW GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		14				14				15		
NON DOMESTIC												
MAJOR USERS		10				10				10		
MINOR USERS		10				11				12		
SUBTOTAL	22	34	51	75	23	35	53	77	23	35	53	77
INFILTRATION AND INFLOW	21	21	27	27	21	21	27	27	21	21	27	27
TOTAL	44	55	78	102	44	56	79	104	44	56	79	104
TOTAL WITH STORM FLOW			182	182			182	182			182	182

Note: 182 mgd maximum capacity

TABLE L-4

FLOWS AT COLUMBUS PARK HEADWORKS  
HIGH GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	<u>Min Day (mgd)</u>	<u>Avg Day (mgd)</u>	<u>Max Day (mgd)</u>	<u>Peak Hour (mgd)</u>	<u>Min Day (mgd)</u>	<u>Avg Day (mgd)</u>	<u>Max Day (mgd)</u>	<u>Peak Hour (mgd)</u>	<u>Min Day (mgd)</u>	<u>Avg Day (mgd)</u>	<u>Max Day (mgd)</u>	<u>Peak Hour (mgd)</u>
DOMESTIC		14					14			15		
NON DOMESTIC												
MAJOR USERS		10					10			10		
MINOR USERS		10					11			12		
SUBTOTAL	22	34	51	75	23	35	53	77	23	35	53	77
INFILTRATION AND INFLOW	49	49	66	66	49	49	66	66	49	49	66	66
TOTAL	71	83	117	141	72	84	119	143	72	84	119	143
TOTAL WITH STORM FLOW			182	182			182	182			182	182

Note: 182 mgd maximum capacity

TABLE L-5

FLOWS AT WARD STREET HEADWORKS  
LOW GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		24				25				25		
NON DOMESTIC												
MAJOR USERS		9				9				9		
MINOR USERS		8				10				11		
SUBTOTAL	28	41	60	88	29	43	63	92	30	44	64	94
INFILTRATION AND INFLOW	43	43	54	54	43	43	54	54	43	43	54	54
TOTAL	71	84	114	142	72	86	117	146	73	87	118	147
TOTAL WITH STORM FLOW			256	256			256	256			256	256
											256	256

Note: 256 mgd maximum capacity

TABLE L-6

FLOWS AT WARD STREET HEADWORKS  
HIGH GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		24				25				25		
NON DOMESTIC												
MAJOR USERS		9				9				9		
MINOR USERS		8				10				11		
SUBTOTAL	28	41	60	88	29	43	63	92	30	44	64	94
INFILTRATION AND INFLOW	97	97	133	133	97	97	133	133	97	97	133	133
TOTAL	125	138	193	221	126	140	195	225	127	141	197	226
TOTAL WITH STORM FLOW			256	256			256	256			256	256

Note: 256 mgd maximum capacity

TABLE L-7

FLOWS AT WINTHROP TERMINAL HEADWORKS  
LOW GROUNDWATER CONDITIONS

	1990			2000			2010			2020		
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		4				5				6		
NON DOMESTIC												
MAJOR USERS		2				2				2		
MINOR USERS		1				1				1		
SUBTOTAL	4	7	13	19	4	8	14	22	4	8	14	22
INFILTRATION AND INFLOW	5	5	6	6	5	5	6	6	5	5	6	6
TOTAL	9	12	19	26	10	13	20	28	10	13	20	28
TOTAL WITH STORM FLOW			125	125			125	125			125	125

Note: 125 mgd maximum capacity

TABLE L-8

FLOWS AT WINTHROP TERMINAL HEADWORKS  
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		4				5				5				6		
NON DOMESTIC																
MAJOR USERS		2				2				2				2		
MINOR USERS		1				1				1				1		
SUBTOTAL	4	7	9	11	4	8	14	22	4	8	14	22	5	9	15	24
INFILTRATION AND INFLOW	11	11	16	16	11	11	16	16	11	11	16	16	11	11	16	16
TOTAL	15	18	25	27	16	19	30	37	16	19	30	37	17	20	31	39
TOTAL WITH STORM FLOW			125	125			125	125			125	125			125	125

Note: 125 mgd maximum capacity



TABLE L-9

FLOWS AT NUT ISLAND TREATMENT FACILITY  
LOW GROUNDWATER CONDITIONS

	1990			2000			2010			2020					
	Min Day (mgd)	Avg Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		48			50				50				51		
NON DOMESTIC															
MAJOR USERS		12			12				12				12		
MINOR USERS		18			18				20				22		
SUBTOTAL	54	78	148	56	80	112	152	57	82	115	156	59	85	119	162
INFILTRATION AND INFLOW	25	25	180	25	25	115	180	25	25	115	180	25	25	115	180
TOTAL	79	103	328	81	105	227	332	82	107	230	336	85	110	234	342
TRANSMISSION CAPACITY			360			360	360			360	360			360	360

Note: 360 mgd maximum hydraulic capacity of the South Metropolitan Sewer

TABLE L-10

FLOWS AT NUT ISLAND TREATMENT FACILITY  
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		48				50				50				51		
NON DOMESTIC																
MAJOR USERS		12				12				12				12		
MINOR USERS		18				18				20				22		
SUBTOTAL	54	78	109	148	56	80	112	152	57	82	115	156	59	85	119	162
INFILTRATION AND INFLOW	145	145	235	300	145	145	235	300	145	145	235	300	145	145	235	300
TOTAL	199	223	344	448	201	225	347	452	202	227	350	456	205	230	354	462
TRANSMISSION CAPACITY			360	360			360	360			360	360			360	360

Note: 360 mgd maximum capacity of the South Metropolitan Sewer

TABLE L-11

**BOD LOADING BREAKDOWN  
BY NORTH AND SOUTH SYSTEMS  
(lb/day)**

	<u>North System</u>	<u>South System</u>	<u>Total</u>
1986 Annual Ave	328,000	172,000	500,000
Max 1-day	655,000	345,000	1,000,000
Max 3-day	491,000	259,000	750,000
Max 15-day	458,000	242,000	700,000
Max 30-day	426,000	224,000	650,000
1990 Annual Ave	331,000	174,000	505,000
Max 1-day	662,000	348,000	1,010,000
Max 3-day	496,000	262,000	758,000
Max 15-day	463,000	244,000	707,000
Max 30-day	430,000	226,000	656,000
2000 Annual Ave	352,000	185,000	537,000
Max 1-day	703,000	371,000	1,074,000
Max 3-day	528,000	277,000	805,000
Max 15-day	492,000	259,000	751,000
Max 30-day	457,000	241,000	698,000
2010 Annual Ave	363,000	191,000	554,000
Max 1-day	726,000	382,000	1,108,000
Max 3-day	544,000	287,000	831,000
Max 15-day	508,000	267,000	775,000
Max 30-day	472,000	248,000	720,000
2020 Annual Ave	373,000	197,000	570,000
Max 1-day	747,000	393,000	1,140,000
Max 3-day	560,000	295,000	855,000
Max 15-day	523,000	275,000	798,000
Max 30-day	485,000	256,000	741,000

TABLE L-12

**TSS LOADING BREAKDOWN  
BY NORTH AND SOUTH SYSTEMS**  
(lb/day)

		<u>North System</u>	<u>South System</u>	<u>Total</u>
1986	Annual Ave	291,000	154,000	445,000
	Max 1-day	612,000	322,000	934,000
	Max 15-day	437,000	230,000	667,000
	Max 30-day	379,000	199,000	578,000
1990	Annual Ave	295,000	155,000	450,000
	Max 1-day	619,000	326,000	945,000
	Max 15-day	442,000	233,000	675,000
	Max 30-day	383,000	202,000	585,000
2000	Annual Ave	315,000	166,000	481,000
	Max 1-day	662,000	348,000	1,010,000
	Max 15-day	472,000	249,000	721,000
	Max 30-day	410,000	216,000	626,000
2010	Annual Ave	326,000	172,000	498,000
	Max 1-day	685,000	361,000	1,046,000
	Max 15-day	489,000	258,000	747,000
	Max 30-day	424,000	223,000	647,000
2020	Annual Ave	337,000	178,000	515,000
	Max 1-day	708,000	373,000	1,081,000
	Max 15-day	506,000	266,000	772,000
	Max 30-day	438,000	231,000	669,000

TABLE L-13

NORTH SYSTEM  
STORM LOADINGS  
(lb/day)

<u>Year</u>	<u>BOD</u>	<u>TSS</u>
1986	493,000	691,000
1990	496,000	695,000
2000	517,000	715,000
2010	528,000	726,000
2020	538,000	737,000





## Appendix M



**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix M  
Stacked Clarifiers**

## APPENDIX M

### SECONDARY TREATMENT FACILITIES PLAN

#### SEDIMENTATION USING STACKED CLARIFIERS

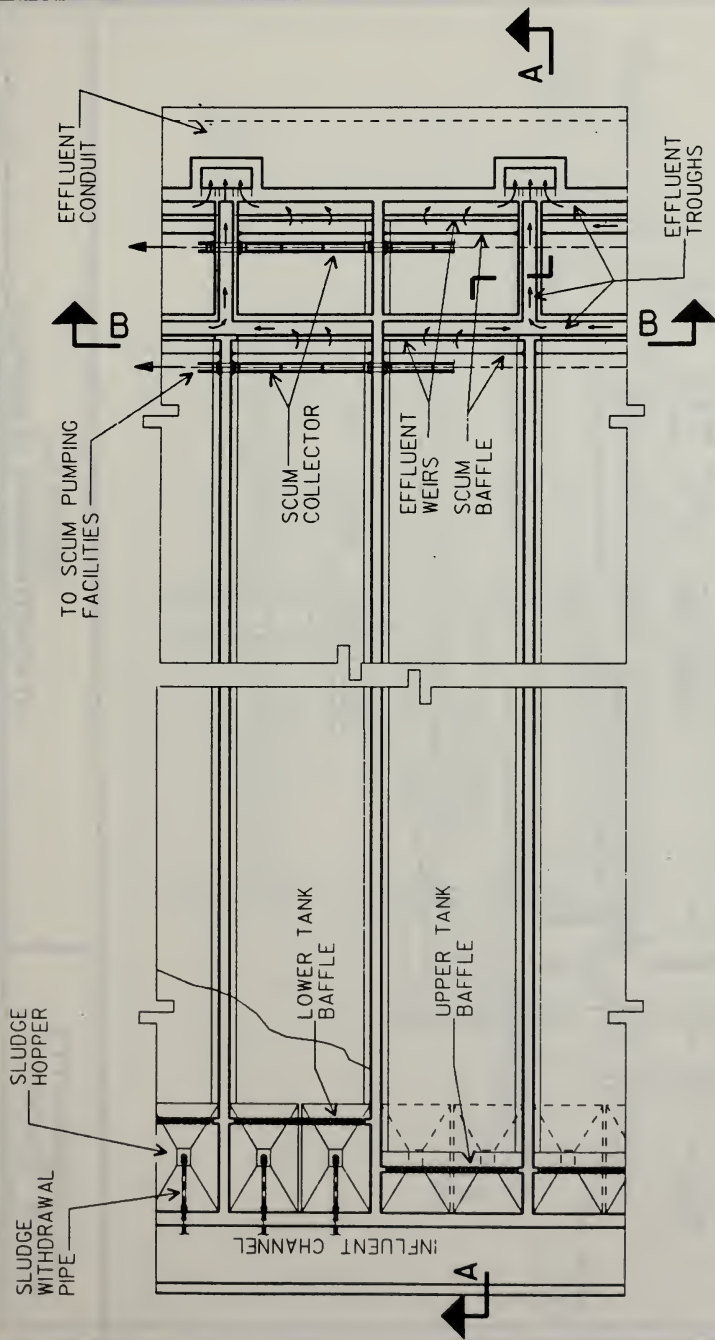
##### INTRODUCTION

New treatment facilities at Deer Island will include preliminary, primary and secondary treatment and disinfection. An integral part of primary and secondary treatment is the settling or sedimentation process which takes place in primary and secondary clarifiers. Various types and shapes of clarifiers were investigated during the screening of the unit processes for the Secondary Treatment Facilities Plan. The Report on Evaluation and Screening of Unit Processes, December 1986, identified conventional unstacked rectangular clarifiers and stacked rectangular clarifiers for further evaluation. Conventional rectangular clarifiers are a proven and effective means for settling solids and are more land-efficient than circular clarifiers. Stacked rectangular clarifiers were selected for further evaluation based on additional land area savings over conventional rectangular clarifiers.

Stacked rectangular clarifiers operate similarly to conventional rectangular clarifiers in terms of influent and effluent flow patterns and sludge collection and removal. The stacked clarifiers are actually two tanks, one above the other, operating on a common water surface. Each clarifier (tank) is fed independently, resulting in parallel flow through the upper and lower tanks. Settled solids are collected from each tank by chain and flight collectors discharging to a common hopper. The effluent from both the upper and lower tanks discharges to transverse weirs. The distinction between parallel-flow stacked clarifiers and series-flow trayed clarifiers is that the trayed clarifiers are arranged such that flow travels through one tank and then through the other tank. Trayed clarifiers have been used for sedimentation in water treatment facilities, but not in municipal wastewater treatment plants. The trayed clarifiers were not considered because of a lack of wastewater-related operating history, and because of the different settling characteristics of solids in water and in wastewater.

Preliminary layouts of the planned treatment plant on Deer Island included conventional rectangular primary and secondary clarifiers, stacked primary and secondary clarifiers, and a combination of the stacked primary and conventional secondary clarifiers. The layouts showed that the completely conventional layout alternative occupied nearly the entire island, required that all excavated material be transported off-site, infringed on buffering berms, limited open space, and infringed on potential historical and archaeological sites. The stacked primary and conventional secondary clarifiers layout alternative used almost the entire island as well, allowed for small visual buffering berms, and limited open space to the area nearest Point Shirley. The use of stacked primary and stacked secondary clarifiers most closely meets mitigation commitments and site planning goals.

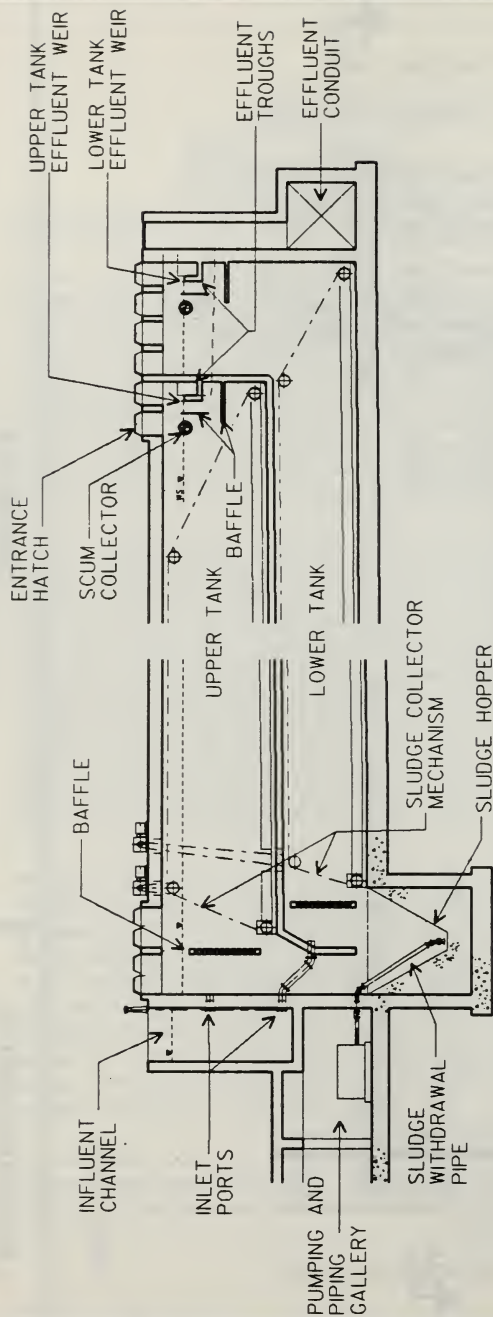
Plan and section views of the stacked primary clarifiers proposed for use at Deer Island are shown in Figures M-1, M-2 and M-3. The secondary clarifiers are configured in much the same way, with the only significant difference being the double transverse weirs provided for each



SCALE: 1" = 20'

FIGURE M-1  
STACKED PRIMARY CLARIFIERS  
PLAN VIEW

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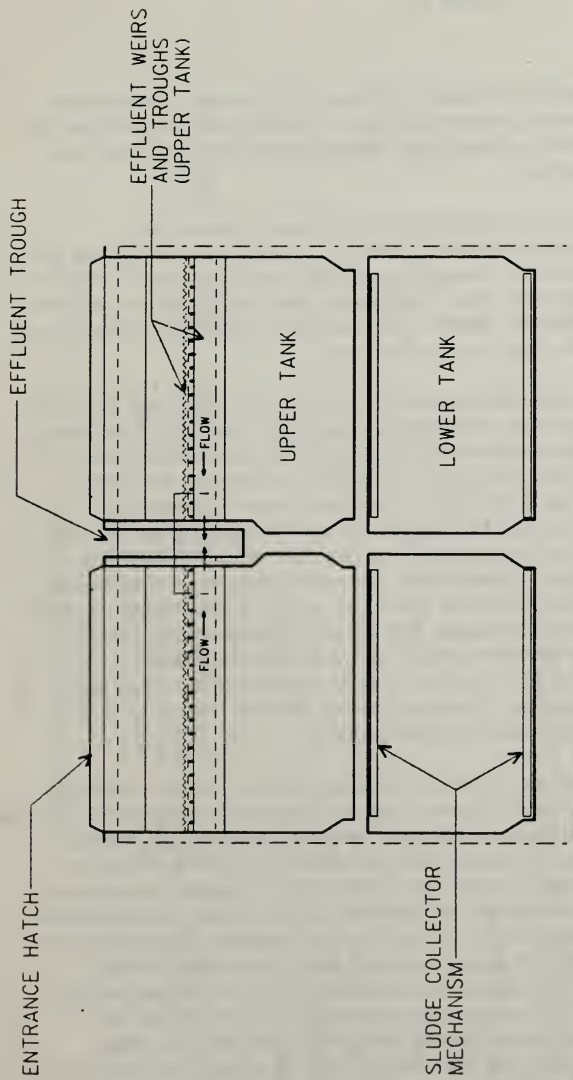
## SECTION A-A

SCALE: 1" = 20'

MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY

FIGURE M-2  
STACKED PRIMARY CLARIFIERS  
LONGITUDINAL SECTION





SCALE: 1" = 10'

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WATER RESOURCES  
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FIGURE M-3  
STACKED PRIMARY CLARIFIERS  
CROSS SECTION

tank as shown in the section view in Figure M-4.

## EXPERIENCE

Operating history for conventional rectangular clarifiers at large wastewater treatment plants in the United States has been successful for many years. Table M-1 presents the effluent TSS concentrations that are achieved by selected large treatment plants in the United States using conventional rectangular clarifiers.

Stacked rectangular clarifiers have been used effectively in Japan for primary and secondary wastewater sedimentation for over 13 years. Stacked units are currently being used in Japan at 37 municipal wastewater treatment plants ranging in design size from 16 mgd to 477 mgd. The average, peak, and design flows of the Japanese plants using primary or secondary stacked clarifiers having a peak flow capacity of over 100 mgd are presented in Tables M-2 and M-3. Clarifier operating data is also shown in these tables.

For the stacked primary clarifiers, the average design surface overflow rates range from 500 to 1200 gpd/ft<sup>2</sup>. The side water depth of the clarifiers ranges from 7.9 to 12.5 ft. The average overflow rates for the stacked secondary clarifiers range from 360 to 860 gpd/ft<sup>2</sup> while the average solids loading rates range from 5.3 to 13.5 lb/d/ft<sup>2</sup>. The sidewater depth of the secondary clarifiers ranges from 8.5 to 14.8 ft. The stacked secondary clarifiers have operated very successfully, as indicated by effluent BOD and TSS concentrations. For both parameters, the average effluent concentrations at each plant are less than 15 mg/l. The stacked clarifiers' effectiveness in removing solids is also shown in the graph of the average surface overflow rates versus effluent TSS in Figure M-5, and in the solids loading rate versus effluent TSS plot in Figure M-6. Comparison of the effluent TSS concentrations from the Japanese plants using stacked clarifiers to those of the United States plants using conventional clarifiers, in Figures M-5 and M-6, indicates that the stacked clarifiers perform as well as the conventional clarifiers. There is no apparent difference between the solids removal effectiveness of the stacked and unstacked clarifiers.

Japanese engineers have reported that scum has not caused operating problems at either the primary or secondary effluent weirs. However, scum has been known to accumulate on the ceiling of the lower clarifiers. Recent Japanese engineering designs have controlled this problem by using chain and flight collectors to pull the scum to the effluent end of the lower clarifier for removal. Oil and grease levels of the influent wastewater to the Japanese plants presented in Table M-4 may be used as an indicator of potential for scum formation. The grease and oil concentration that may be expected in the Deer Island influent, based on the sampling program developed for the Facilities Plan and historic operational data, is approximately 35 mg/l. This volume is in line with the grease and oil concentrations coming into the Japanese plants. Therefore, it is expected that the stacked clarifiers at Deer Island will also perform well. At Deer Island, scum entering the clarifiers will be scraped by chain and flight sludge collectors along the water surface of the upper tank and along the ceiling of the lower tank to the effluent end of the tanks. Scum will be collected and removed before it reaches the effluent weirs.

Table M-1

Conventional Rectangular Secondary Clarifier  
Operating Data

Plant	City	Ave Daily Flow <sup>(1)</sup> (MGD)	Ave. Aeration Tank MLSS (mg/l)	Ave. Solids Loading Rate <sup>(2)</sup> (lb/d/ft <sup>2</sup> )	Ave. Overflow Rate <sup>(2)</sup> (gpd/ft <sup>2</sup> )	Annual Ave. Effluent BOD (mg/l)	Annual Ave. Effluent TSS (mg/l)	Clarifier Depths <sup>(4)</sup> (ft)	Clarifier Lengths <sup>(4)</sup> (ft)
Joint WPCP	Los Angeles	100	3000	25	550	12	12	14	167
Blue Plains-E	Washington D.C.	144	2460	13	633	11	19	12	260
Blue Plains-W	Washington D.C.	169	2700	18	797	18	35	11.7	241
Wards Island	New York	305	780	9	1080	8	13	13	176
							13	13	240
Tallman Island	New York	63	1200	9	780	7	9	12	189
								12	272

(1) Average Daily Flow To Secondary Treatment

(2) Average solids loading rates presented were obtained directly from the treatment plants or calculated based on the average daily flows, MLSS concentrations and clarifier surface areas obtained from the treatment plants.

(3) Average overflow rates presented were obtained directly from the treatment plants or calculated based on the average daily flows and clarifier surface areas obtained from the treatment plants.

(4) Additional clarifier lengths and depths are presented when the treatment plant has secondary clarifiers with different dimensions.

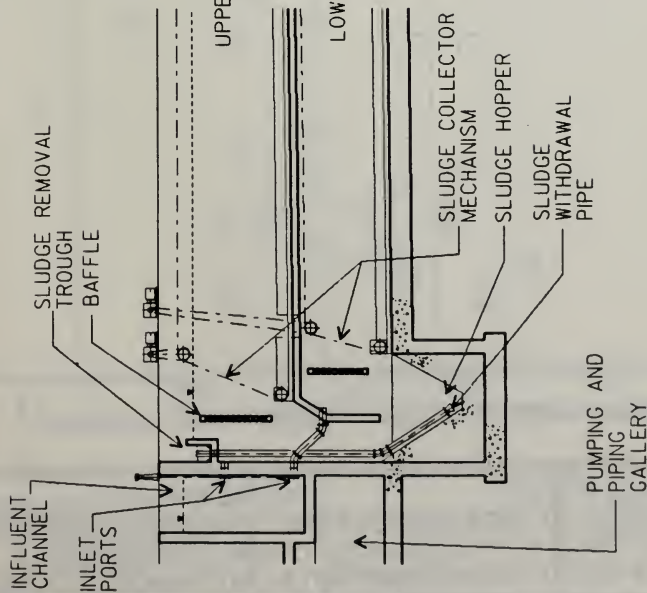
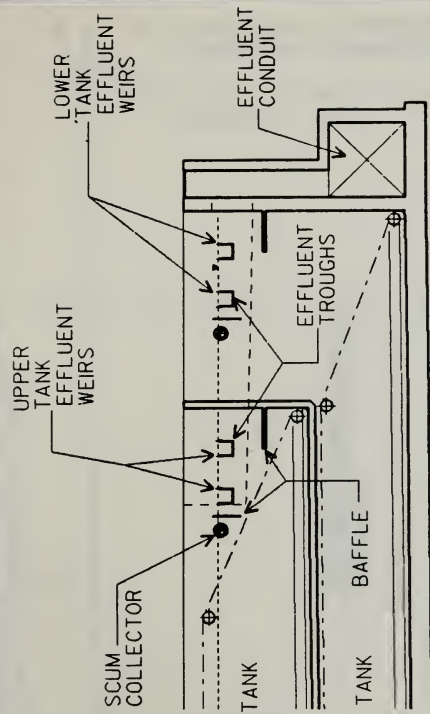
Table M-2

Japanese Wastewater Treatment Plant  
Operating Data For Primary Stacked Clarifiers

Plant	City	Flow		Design Overflow Rate (gpd/ft <sup>2</sup> )	Clarifier Depth per Tray (ft)		Clarifier Length per Tray (ft)	
		Daily Ave(MGD)	Design Ave(MGD)		Upper	Lower	Upper	Lower
Mikawashima	Tokyo	213	251	376	500 to 1230	11.5	11.5	
Shibaura	Tokyo	356	420	630	500 to 1230	12.1	12.5	169
					12.8	14.8	112	131
Morigasaki-E.	Tokyo	406	477	717	500 to 1230	9.8	9.8	131
					12.1	12.1	114	131
Shingashi	Tokyo	312	367	550	500 to 1230	12.8	11.1	123
Kosuge	Tokyo	101	119	178	500 to 1230	7.9	7.9	NA
Shibata	Nagoya	50	67	101	1030	9.8	9.8	NA
Uchide	Nagoya	55	74	111	1230			
Toba	Kyoto	250	323	461	980	10.2	10.2	NA
Higashinada	Kobe	69	92	181	610	11.5	11.5	NA
Hiakari	Kitakyushu	76	96	143	740	12.1	12.1	NA

(1) Design overflow rates were obtained directly from Japanese engineers.

(2) The abbreviation NA indicates that the information is not available.

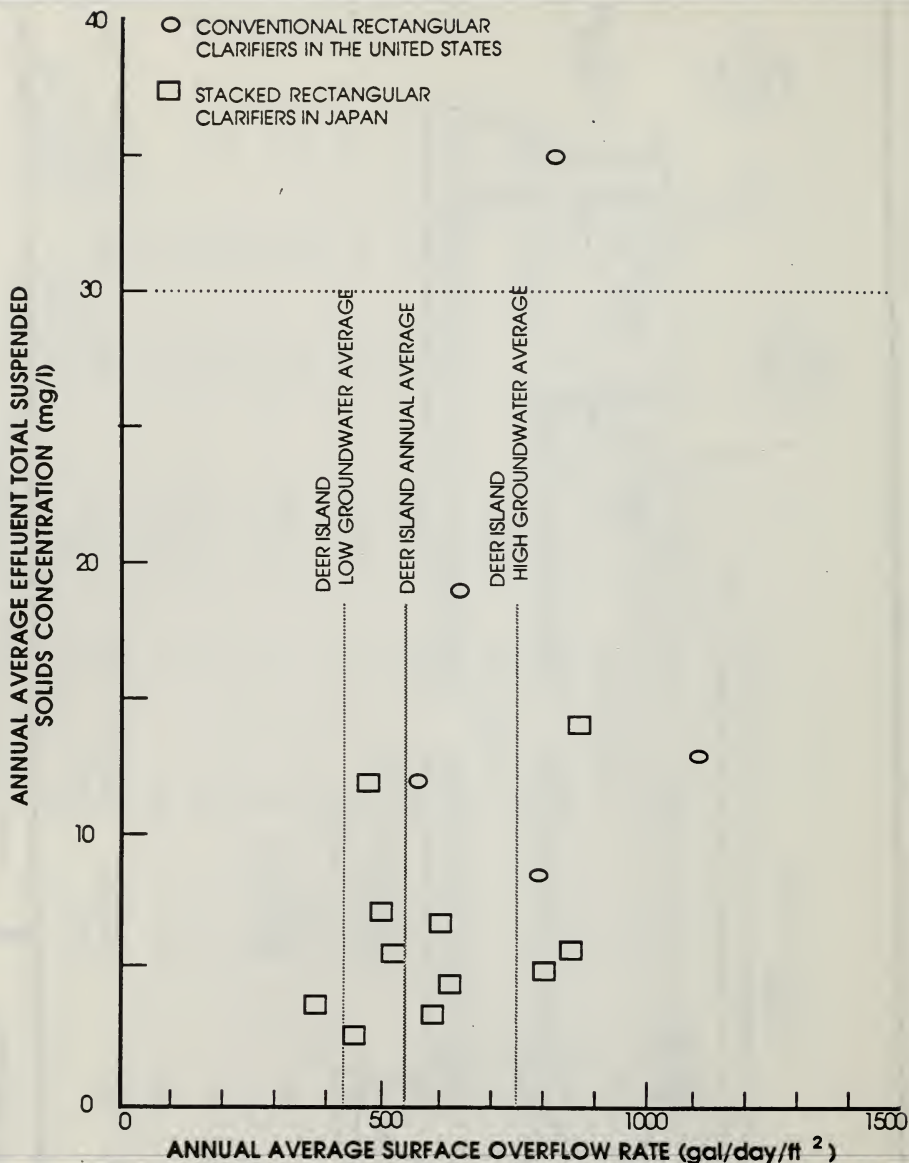


SCALE: 1" = 20'

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FIGURE M-4  
STACKED SECONDARY CLARIFIERS  
LONGITUDINAL SECTION

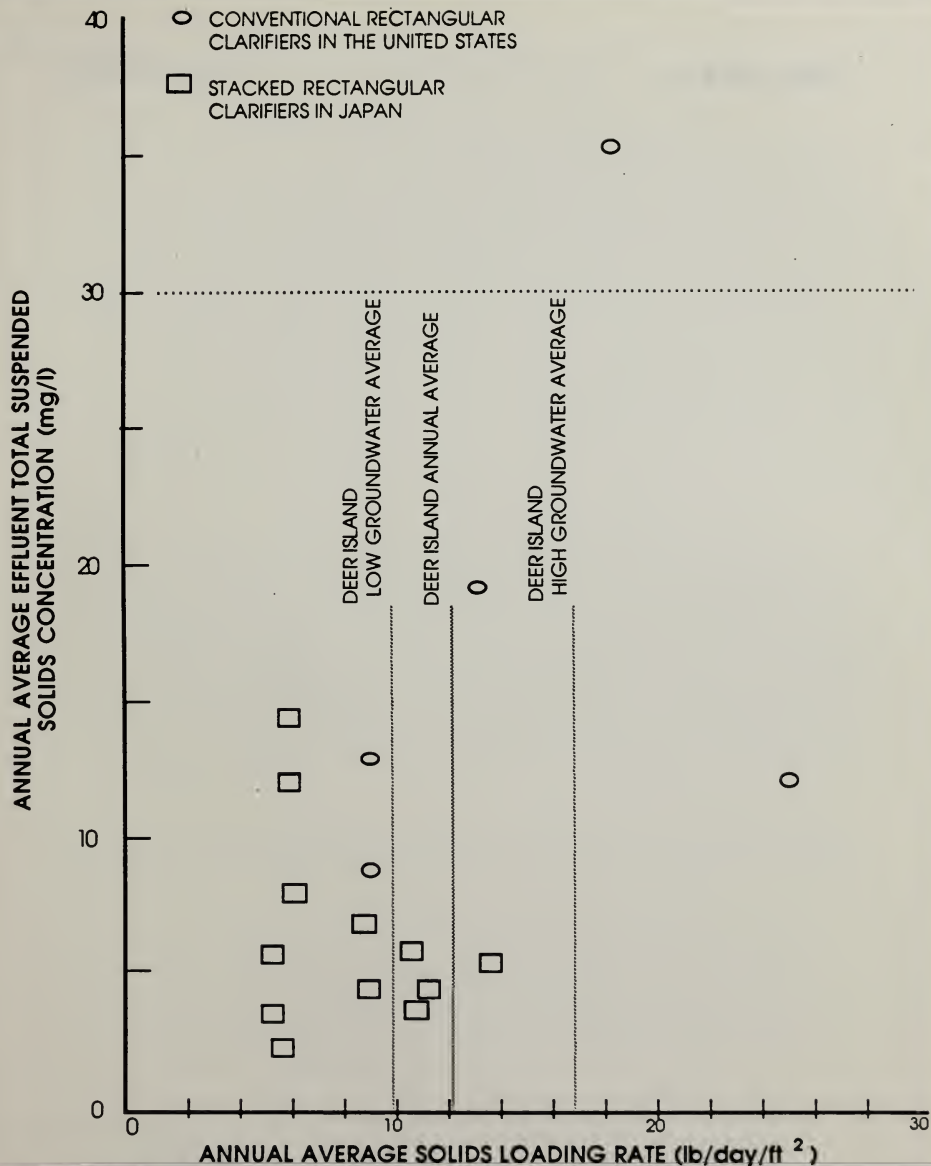




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FIGURE M-5  
RECTANGULAR SECONDARY CLARIFIERS -  
SURFACE OVERFLOW RATE VS.  
EFFLUENT TOTAL SUSPENDED SOLIDS





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FIGURE M-6  
RECTANGULAR SECONDARY CLARIFIERS -  
SOLIDS LOADING RATE VS.  
EFFLUENT TOTAL SUSPENDED SOLIDS

INSERT TABLE M-2

INSERT TABLE M-3

Table M-4

Influent Grease and Oil Concentrations  
at Japanese Wastewater Treatment Plants

Plant	City	Ave Daily Flow (MGD)	Oil and Grease Content (mg/l)
Mikawashima	Tokyo	213	12.2
Shibaura	Tokyo	356	11.0
Ochiai	Tokyo	133	13.5
Morigasaki	Tokyo	406	8.0
Shingashi	Tokyo	312	24.8
Toba	Kyoto	250	3.0
Higashinada	Kobe	69	45.5
Seibu	Kobe	38	32.5
Hiakari	Kitakyushu	76	122.0

Ave. = 30.3

## STACKED RECTANGULAR CLARIFIERS FOR DEER ISLAND

### Primary Clarifiers

For new primary treatment facilities at Deer Island, the stacked parallel flow clarifiers were sized based on a peak surface overflow rate of  $2000 \text{ gpd/ft}^2$  for each clarifier. At peak flow of 1270 mgd, 190 mgd passes through fine screens instead of receiving secondary treatment. The flow that passes through the screens is taken from one battery whose overflow rate is maintained at the average daily rate of  $1200 \text{ gpd/ft}^2$ . The overflow rate in the remaining three batteries is  $2300 \text{ gpd/ft}^2$ . During the time period when the new primary treatment facilities are operating and the secondary treatment facilities are under construction, all of the primary batteries will be loaded equally. The peak overflow rate is well within the  $3000 \text{ gpd/ft}^2$  guideline presented in TR-16 and the EPA Design Manual. The minimum depth of the primary clarifiers is 12 ft, which is within the range of the depths of the Japanese stacked clarifiers as reported in Table M-2. The depth also conforms to the guidelines set by TR-16 and the Ten States Standards.

### Secondary Clarifiers

Planning of the stacked secondary clarifiers at Deer Island is based on existing design standards, current engineering practice, operational experience in Japan, and discussions with MWRA review consultants. The high groundwater average overflow rate of  $750 \text{ gpd/ft}^2$  for the activated sludge system clarifiers is within the  $400$  to  $800 \text{ gpd/ft}^2$  guideline range established by TR-16 and the EPA Design Manual, and the  $800 \text{ gpd/ft}^2$  guideline of MOP8. The peak overflow rate of  $1200 \text{ gpd/ft}^2$  meets TR-16 and Ten States Standards Guidelines. The Deer Island high groundwater average overflow rate is also within the range of the average overflow rates at the Japanese plants. Figure M-5 suggests that for the high groundwater average overflow rate used to size the secondary clarifiers on Deer Island, effluent suspended solids concentrations below  $15 \text{ mg/l}$  could be expected.

The minimum 13-ft side water depth of the secondary clarifiers is within the guideline range of the above mentioned publications, and between the maximum and minimum depths of the listed Japanese plants.

The solids loading rate for the Deer Island secondary clarifiers at the high groundwater average daily flow of 670 mgd is  $16.6 \text{ lb/d/ft}^2$ ,  $9.7 \text{ lb/d/ft}^2$  at the 390 mgd low groundwater average daily flow, and  $12.0 \text{ lb/d/ft}^2$  at the annual average flow of 480 mgd. The annual average solids loading rates of the Japanese plants are somewhat lower than the average rates of the Deer Island secondaries. This does not appear to be a problem, but solids loadings should be confirmed through pilot studies.

In addition to providing effective primary and secondary settling, the proposed stacked clarifier configuration used for this project has certain advantages over conventional rectangular clarifiers and other stacked configurations. For stacked primary clarifiers, sludge piping and pumping equipment requirements are approximately one half of that for conventional units. For secondary sludge removal, piping and valving costs are also reduced.

Also, the overall manageability of a treatment plant is improved as the size of the plant footprint is reduced.

When developing the layout of the stacked clarifiers for Deer Island, the design drawings of five Japanese stacked clarifiers were reviewed. The clarifier designs were similar, yet offered different features. The design features of the Japanese clarifiers that are best suited to the Deer Island primary and secondary clarifiers have been adopted. The proposed method for introducing flow to each Deer Island primary and secondary clarifier directs the flow from an influent channel through two inlet ports to the upper tank, and through two pipes to the lower tank. The flow to the lower tank is piped past the sludge hoppers to the head of the lower tank to prevent the influent flow from interfering with the settling of upper tank solids to the sludge hoppers.

The configuration of transverse weirs for the upper and lower clarifiers for both the primary and secondary clarifiers at Deer Island allows for removal of scum from both the upper and lower clarifiers before the flow passes over the effluent weirs. Another benefit of this tank arrangement is direct access to the lower tank in the vicinity of the effluent weirs. Entrance is not as easily attainable for tank geometries using longitudinal effluent weirs along the sides of the tanks. The recommended clarifier arrangement also has full top-to-bottom wall construction between adjacent tanks. Data from Okuno and Fukuda showed that stacked clarifier designs similar to the recommended arrangement for Deer Island have longer actual retention times, higher volumetric efficiencies (less dead space), and are less likely to short circuit than stacked clarifiers having partial wall construction and longitudinal effluent weirs extending closer to the influent openings. The full top-to-bottom wall construction also allows for isolation of just the upper and lower tanks of a stacked set when taking one tank out of service. In essence, only the surface area of two tanks is lost in order to take one tank out of service. For the stacked clarifiers not using full wall construction, and conventional rectangular clarifiers having widths greater than 40 ft, if one tank must be isolated, greater surface area is taken out of service.

#### COST COMPARISON OF STACKED SECONDARY CLARIFIERS AND CONVENTIONAL SECONDARY CLARIFIERS

Comparison between the costs of stacked and conventional secondary clarifiers indicates that the stacked clarifiers have a present worth value of \$153 million, while conventional units have a present worth value of \$142 million. A summary of the life cycle costs of the secondary clarifiers is presented in Table M-5. Construction costs cover materials, excavation, backfilling, dewatering, and inter-process influent and effluent channels. Equipment costs include sludge collectors, sludge pumps and piping, instrumentation, HVAC, plumbing, and electrical equipment.

The operation and maintenance costs would be essentially the same for either alternative, approximately \$500,000 per year. The power costs would be the same due to the equal number of pumps and sludge collectors, and the equivalent pump operation times. The stacked clarifiers will require additional maintenance efforts when a stacked set is out of operation, due to the unique entry requirements of the lower clarifier. However, this should be offset by the lower



Table M-5

Summary of Life Cycle Costs  
Secondary Clarifiers  
(All costs in millions of dollars)

	<u>Capital Cost</u>	<u>O&amp;M Cost</u>	<u>Project<sup>(1)</sup> Cost</u>	<u>Present Worth January, 1990</u>
STACKED CLARIFIERS				
Equipment	66.0		89.1	54.1
Structures	144.4		194.9	96.5
Annual Operation and Maintenance		0.5		<u>2.0</u>
TOTAL				152.6
UNSTACKED CLARIFIERS				
Equipment	66.0		89.1	54.1
Structures	129.0		174.2	86.2
Annual Operation and Maintenance		0.5		<u>2.0</u>
TOTAL				142.3

<sup>(1)</sup> Project costs include engineering and contingencies.

maintenance and operation requirements of a smaller, more manageable treatment plant.

## SECONDARY CLARIFIERS SITING CONSIDERATIONS

As stated in the introduction to this Appendix, the siting of the stacked and conventional secondary clarifiers includes several siting goal trade-offs. The construction of stacked secondary clarifiers allows for the construction of a berm at the north end of the island large enough to screen the treatment plant from Point Shirley and other areas of Winthrop, as well as to keep the plant as far away from Point Shirley residents as possible. Of the two site layout alternatives, the alternative incorporating a berm and stacked clarifiers provides for the greatest amount of noise attenuation. The layout incorporating stacked clarifiers also provides much more available open space.

Movement of earth on and off the island also varies for each alternative. The quantity of material excavated for the stacked alternative is 780,000 yd<sup>3</sup> out of a total excavation of 3,500,000 yd<sup>3</sup>, while the shallower conventional alternative requires excavation of 380,000 yd<sup>3</sup> out of a total excavation of 3,100,000 yd<sup>3</sup>. This difference in excavation volume is offset in part by the 220,000 yd<sup>3</sup> of structural fill needed to construct the conventional alternative as opposed to the 60,000 yd<sup>3</sup> of fill needed for stacked clarifiers. The structural fill will most likely have to be purchased and transported to the island. The differences in excavation, fill and earth movement quantities for construction are incorporated in the cost estimates. For the treatment plant layout incorporating stacked clarifiers, the amount of excavation material reused on-site is approximately 2,800,000 yd<sup>3</sup> with an off-site movement of approximately 700,000 yd<sup>3</sup> (excluding off-site removal of demolition and tunnel spoils). For the conventional alternative the amount of excavation material reused on-site is approximately 2,100,000 yd<sup>3</sup> with an off-site movement of approximately 1,000,000 yd<sup>3</sup>. The conventional alternative requires an additional 300,000 yd<sup>3</sup> of material to be moved off the island, which is a direct result of the reduction of the size of the berm on the north side of the island.

## CONCLUSION

The stacked primary and secondary clarifiers recommended for the Deer Island Secondary Treatment Plant conform to existing design standards and engineering practice and are expected to provide excellent treatment. Data gleaned from Japanese treatment plants' use of stacked clarifiers has been incorporated into the Deer Island planning to ensure efficient and easily-maintained clarifiers. Construction, operation, and maintenance of stacked secondary clarifiers at Deer Island would cost approximately 7 percent more than conventional clarifiers. Also, a treatment plant site incorporating stacked primary and secondary clarifiers most closely meets the site planning goals and project mitigation commitments.

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Table M-3  
Japanese Wastewater Treatment Plant  
Operating Data For Secondary Stacked Clarifiers

Plant	City	Flow		Design Aeration Tank MLSS (mg/l)	Ave Solids Loading Rate <sup>(1)</sup> (lb/d/ft <sup>2</sup> )	Overflow Rate <sup>(1)</sup> Ave		Effluent BOD (mg/l)	Effluent TSS (mg/l)	Clarifier Depths per Tray (ft)		Clarifier Lengths per Tray <sup>(2)</sup> (ft)	
		Daily Ave (MGD)	Peak (MGD)			Peak	ft <sup>3</sup> /d			Upper	Lower	Upper	Lower
Mikawashina	Tokyo	213	251	376	1700	13.5	830	1460	6	11.5	11.5	148	134
Shibaaura	Tokyo	356	420	630	2690	8.4	590	1050	7	14.8	14.8	117	131
Ochiai	Tokyo	133	156	234	2650	5.9	860	1520	12	8.9	9.2	134	145
Morigasaki-E.	Tokyo	406	477	717	2620	5.7	430	770	3	9.5	8.5	180	180
Shingashi	Tokyo	312	367	550	2490	10.8	750	1320	5	12.8	10.5	109	161
Konuge	Tokyo	101	119	178	2670	8.8	610	1070	4	11.5	11.2	NA	NA
Kasai	Tokyo	211	248	372	2000	5.3	360	630	2	9.8	9.8	NA	NA
Shibata	Nagoya	50	67	101	NA	6.2	480	960	14	9.8	9.8	NA	NA
Uchide	Nagoya	55	74	111	NA	10.5	500	1020	7	11.5	11.5	NA	NA
Toba	Kyoto	250	323	461	2150	5.3	510	940	9	10.2	10.2	NA	NA
Higashinada	Kobe	69	92	181	2200	5.8	470	1220	11	10.8	10.8	NA	NA
Hikari	Kinki-yushu	76	96	143	1740	10.7	560	1060	5	10.2	10.2	NA	NA

(1) Average solids loading and surface overflow rates were obtained directly from Japanese engineers.

(2) Additional clarifier lengths and depths are presented when the treatment plant has secondary clarifiers with different dimensions.

(3) The abbreviation NA indicates that the information is not available.







**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix N  
Abbreviations**

## APPENDIX P

### LIST OF ABBREVIATIONS

atmosphere	atm
average	avg
biochemical oxygen demand (5-day)	BOD
brake horsepower	bhp
British thermal unit	Btu
carbon monoxide	CO
centimeter	cm
chemical oxygen demand	COD
combined sewer overflow	CSO
cubic foot	ft <sup>3</sup>
cubic feet per minute	cfm
cubic feet per second	cfs
cubic meter	m <sup>3</sup>
cubic yard	cu yd
decibel	dB
decibel A weighted	dBA
degree	deg. or °
degree centigrade	C
degree Fahrenheit	F
diameter	dia
dissolved oxygen	DO
elevation	elev
feet per minute	fpm
feet per second	fps
food to microorganism ratio	F/M
foot	ft
gallon	gal
gallon per minute	gpm
gallon per day	gpd
gram	g
heating, ventilating and air conditioning	HVAC
Hertz	Hz
horsepower	hp
hour	hr

inch	in
infiltration/inflow	I/I
kilovolt	kv
kilovolt amperes	kva
kilowatt	kw
kilowatt hour	kwh
linear foot	linear ft
liquid oxygen	LOX
meter	m
megawatts	Mw
microgram	$\mu$ g
milligram	mg
milligrams per liter	mg/l
milliliter	ml
million gallon	mil gal
million gallons per day	mgd
minimum	min
mixed liquor suspended solids	MLSS
mixed liquor volatile suspended - solids	MLVSS
nitrogen oxides	NO <sub>x</sub>
parts per billion	ppb
parts per million	ppm
pound	lb
return activated sludge	RAS
revolutions per minute	rpm
second	sec
side water depth	swd
sludge volume index	SVI
sodium hypochlorite	NaOCl
solids retention time	SRT
specific gravity	sp gr
square foot	ft <sup>2</sup>
standard cubic foot per minute	scfm
sulfur dioxide	SO <sub>2</sub>
suspended solids	SS
tons per day	tpd
total dynamic head	tdh
total suspended particulate	TSP
total suspended solids	TSS
total kjeldahl nitrogen	TKN
ultraviolet	UV
volatile organic compound	VOC
volt	v
waste activated sludge	WAS
watt	w

weight  
yard  
year

wt  
yd  
yr







**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix O**  
**Bibliography**

## APPENDIX O

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**Secondary Treatment Facilities Plan**

**Volume III**

**Appendix P**  
**Archaeology**

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## APPENDIX P

### ARCHAEOLOGICAL REPORT

#### 1.0 SUMMARY

This Appendix is a summary of the complete Archaeological Report which will appear in Volume II of the Secondary Treatment Facilities Plan.

The Public Archaeology Laboratory, Inc. conducted an intensive archaeological survey of The New Resthaven historic cemetery site at the Deer Island House of Correction, Boston, Massachusetts. The combined resources of in-depth documentary research, geophysical/remote sensing survey, and archaeological subsurface testing were utilized. The cemetery site is located on the hillside east of the Hill Prison building. Burials are restricted to the area above the mausoleum and extend northeast some 30 to 40 meters. Preservation of the burials within the cemetery is very bad. No further archaeological work is recommended.

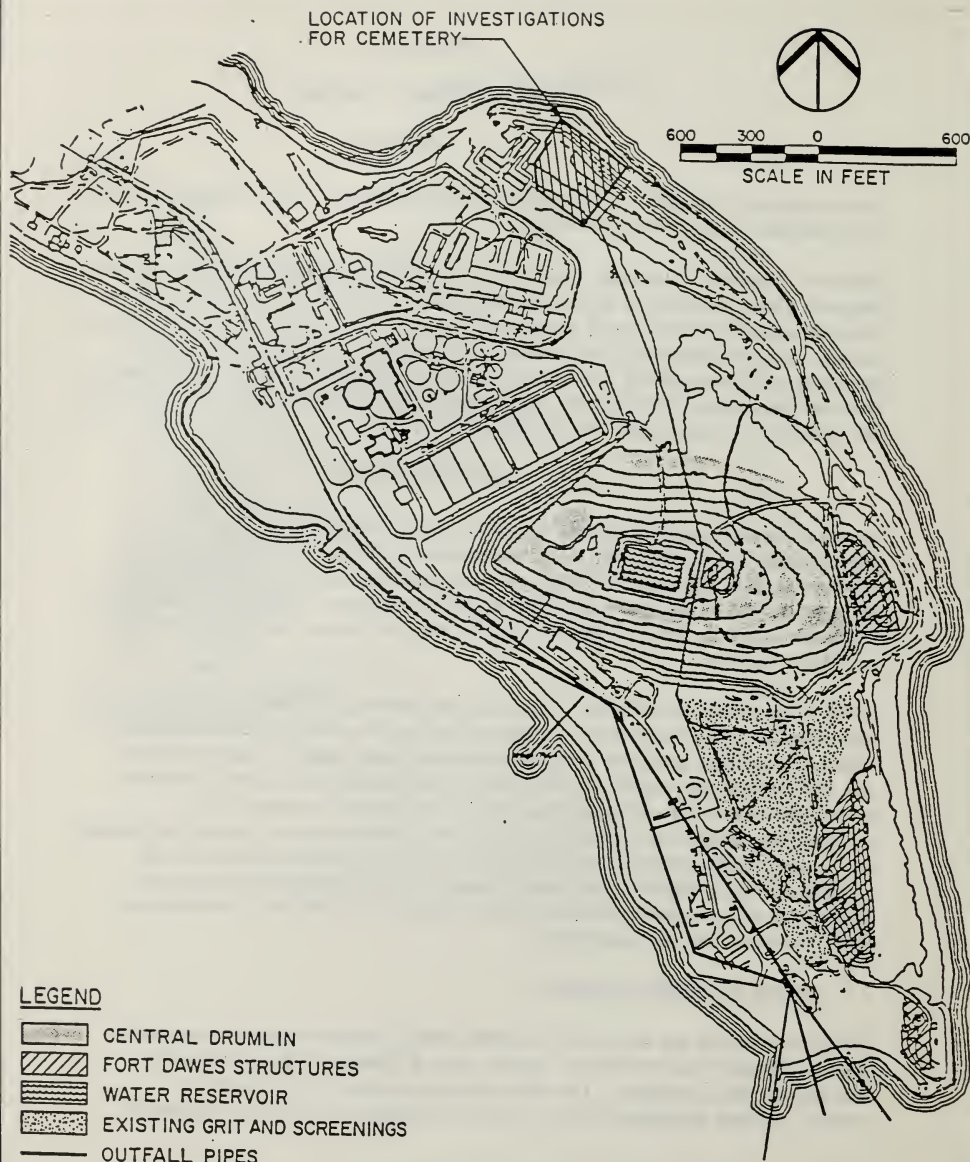
#### 2.0 INTRODUCTION

As part of the planning process for the secondary treatment facilities project, a reconnaissance level archaeological survey was conducted in September 1985 to identify and document standing structures of historic interest and significance on Deer Island and assess the extent of previous disturbance within the designated project area. Another purpose of the reconnaissance survey was to analyze the impact or effect the proposed development would have on cultural resources.

In the course of this reconnaissance survey an historic cemetery and mausoleum were identified within the Deer Island project area. The cemetery plot and associated vault are located on a slope on the northeast side of the island between the old piggery and the concrete boundary wall that originally separated the City of Boston property from the U.S. military reservation on the southern half of Deer Island (Figure P-1). It is referred to hereafter as the northeast, new cemetery, or New Resthaven Cemetery. Based on current plans for the proposed Deer Island secondary treatment facilities Resthaven, it is clear that the cemetery site will be within the area of impact from this development. It was recommended that additional documentary and, if necessary, archaeological investigations be conducted to provide more specific information on the cemetery site.

#### 2.1 RESEARCH TASKS/OBJECTIVES

This intensive survey was carried out in two basic steps or stages consisting of documentary research followed by site verification. Specific research objectives or goals were set for both stages of this investigation. This report describes the results of both stages of research. In-depth documentary research focused specifically on the history of cemeteries



**MASSACHUSETTS  
WATER RESOURCES  
AUTHORITY**

**FIGURE P-1  
LOCATION OF CEMETERY INVESTIGATIONS**



related to the various institutions (quarantine station, almhouse, prison/correctional facilities) that have been located on Deer Island. Site verification, including remote sensing and subsurface testing, focused on the determination of horizontal boundaries and internal configuration of the cemetery.

## 2.2 DOCUMENTARY RESEARCH

The specific objectives established for the documentary research were: (1) to establish the period of active use of the one known cemetery within the project area (identified during reconnaissance survey); (2) to establish whether this cemetery is older than the 1908 mausoleum associated with it; (3) to determine, if possible, whether the known cemetery contains any burials that were removed from earlier nineteenth century plots formerly located on other sections of Deer Island; (4) to determine if the cemetery plot near the 1908 mausoleum could contain older (nineteenth century?) reinterred burials; (5) to consult records maintained by the military (Army Corps of Engineers) for any information relevant to the final disposal of burials from Resthaven Cemetery; (6) to determine when Resthaven Cemetery on the southern tip of Deer Island was first actively used by the correctional facilities; and finally (7) to locate documentary sources describing the methods used in the burial of the almshouse or prison inmates on Deer Island (individual graves, large trenches, etc).

## 2.3 SOURCES

A wide variety of sources were consulted in the course of this research. As the City of Boston has no centralized archive or depository for records pertaining to city institutions and no listing of where such documents are located, a major effort was needed merely to track down documentation which has survived intact. During the move to the new City Hall a number of city records were apparently lost or discarded (Captain Swanson and Libby Bouvier, personal communication 1987).

Institutions like those on Deer Island have long and complex histories, particularly when the operation of such facilities has shifted between various city departments or from city to state or federal agencies or jurisdiction. Of primary importance to this research were documents of the different City of Boston boards of directors, committees and departments which have controlled the numerous Deer Island institutions during the past 140 years. Included among these were Annual Reports of the Public Institutions and Penal Institutions departments, the Houses of Industry, Reformation and Correction, the Overseers of the Poor, the Harbor Master and City Auditor. The documents were located in the Massachusetts State Library and provided valuable information.

Unfortunately, although daily and weekly reports of the immediate supervisors of the institutions (including specific information concerning inmates admitted and discharged, physical examinations, visitors to the institutions, and log books of the Houses of Industry and Correction) were located, they were not readily accessible. Many of these documents, some 318 volumes, discovered in the old prison building following a fire, were only sketchily inventoried by Dr. Dennis P. Ryan and Mr. Earl Hamilton in 1985 prior to their transfer to the

library at Boston College for preservation and cataloging (Penal Department Communication 1985). Cataloging and indexing of the collection has not yet been completed. Dr. Ryan, who looked through much of the material, could not remember seeing listings of deaths or burial locations nor information on cemeteries (Dr. Ryan, personal communication, 1987). Mr. Hamilton provided information concerning a "Death Book" maintained at Deer Island. However, as yet, permission has not been received to visit the island and consult this potentially valuable resource.

In addition to the consultation of city documents, the records of the U.S. Army Corps of Engineers at the National Archives and Records Administration Center in Waltham, Massachusetts were examined. The numerous memos, letters and documents relating to the purchase of the military reservation on the southern portion of the island for harbor defense and the subsequent transaction between city and military officials, provided detailed information on the old City of Boston Cemetery located on the military reservation.

Letters were mailed and/or phone calls made to individuals and departments concerned with or knowledgeable about Deer Island. Among those contacted were Captain Swanson of the Metropolitan District Commission, Earl Hamilton of the Penal Institutions Department, Superintendent Broderick and Mrs. Bondar at the Suffolk County House of Correction on Deer Island, the Cemetery Division of the Parks and Recreation Department, Death Section of the City Clerks Department, and Dr. Dennis P. Ryan, a historian of the Boston Irish and consultant to Burns Library at Boston College.

In the course of several trips to Deer Island to conduct the site verification fieldwork, conversations with guards provided additional information. From Officer Kane we learned how the site has been used in recent years, the locations of a guard dog burial and the burial of pig remains following the destruction of the piggery by fire, and of the impact of storms and seawater upon the site. Another guard informed us of photographs in the MDC archives under the care of Alfred K. Schroeder, which were later consulted.

In addition to these primary sources of data, secondary sources on Boston history, Irish immigration, and other related issues were consulted. These sources provided much of the historical background necessary to understand the public institutions established on Deer Island and the inmates who occupied them.

Working within these constraints, this research has focused on the issue of death and burial at the Deer Island institutions to trace the origins and history of the cemeteries on the island. Historical background on the development of the various public institutions is provided to complete and complement this research goal.

#### 2.4 SITE VERIFICATION

The site verification stage of the research involved two steps, remote sensing and subsurface testing. A program of remote sensing was used to discern any patterns of disturbance which may be present in the cemetery area and which could indicate the presence of burials. The remote

sensing program employed two techniques, soil sensitivity and electron magnetometry. A number of anomalies of differing sensitivity were located and ranked by their priority for testing. Based on the results of the remote sensing a plan was formulated for subsurface testing which included machine excavation and documentation of ten possible trenches within the project area.

### 3.0 PUBLIC INSTITUTIONS ON DEER ISLAND

During the 140 years since the City of Boston took possession of Deer Island in 1847 for "sanitary purposes", the island has served as a repository for individuals and a location for institutions considered undesirable within the core urban area.

More than 25,000 alien passengers, many of them Irish immigrants, arrived in Boston during 1847 (Abbot 1926:589). The numbers of ill and dying arriving in Boston were so great that, during the summer of 1847, a receiving room was constructed at Long Wharf in which these invalids could wait for transportation to hospitals. That year, a quarantine hospital was established on Deer Island for the express purpose of receiving alien passengers "as a precautionary measure to ward off a pestilence that would have been ruinous to the public health and business of the city" (Massachusetts Senate Doc. 46, 1848:10).

Large numbers of these immigrants who were sent to Deer Island never recovered. Of 4,816 persons admitted between the opening of the hospital in June, 1847 and January 1, 1850, 4,069 were sick when admitted and 759 died on the island (Abbott 1926).

In 1849, the City of Boston confirmed its earlier decision to use Deer Island as "the place of quarantine for the Port of Boston" (City Doc. 27, 1849:5). All ships entering Boston Harbor containing passengers or cargo considered to be "foul and infected with any malignant or contagious disease" were required to anchor at Deer Island until such time as the Port Physician gave permission to leave following removal of passengers and cleaning and purification of the vessel (City Doc. 27, 1849:6).

Prior to 1849, the city maintained only one institution on Deer Island, a quarantine station and hospital for immigrants and paupers unable to care for themselves, located on the southern half of the island. Beginning in that year, most of the Deer Island facilities were "occupied as an appendage to the South Boston establishment" of the House of Industry (City Doc. 25, 1849:4). As of March 31, 1849, the Deer Island Department of the House of Industry had 396 inmates. The hospital continued at Deer Island until 1866 when it was replaced by a new hospital on Gallop's Island (Mikal 1873:50).

A brick building was completed in 1852 to house the Deer Island Almshouse and House of Industry located on the northern half of the island. While these two institutions were considered separately in much of the official documentation, a major problem on the island was the close association of the two categories of inmates. The Almshouse was established to serve the virtuous or deserving poor, and these individuals were permitted to live at Deer Island when they were unable to support and care for themselves. Facilities provided for the Almshouse population included a nursery, schools, hospital (shared with other institutions), housing and

workshops.

The inmates of the House of Industry were sentenced by the courts to serve time at Deer Island for misdemeanors and crimes committed in the City, including large numbers of individuals sentenced for drunkenness and idleness. This second category of inmates, the sentenced or vicious poor, were seen as a bad influence on the Almshouse population and on the children within the institution (City Doc. 27, 1857:7; City Doc. 25, 1860:5). However, it was not until construction of additional facilities to relieve overcrowding during the latter half of the nineteenth century that a more or less total separation of the two groups of inmates was accomplished. Meanwhile, the population of those institutionalized grew quickly from the 331 recorded in 1856 to 1,746 inmates in the combined institutions in 1886.

In addition, as early as 1854, Deer Island was being considered for the location of a new House of Correction. In that year the Committee on Public Buildings authorized a portion of the brick building, then housing the Almshouse and House of Industry, to be remodeled by the addition of cells, for use as a prison facility (City Doc. 24, 1856:3). As a result, inmates of the building were redistributed among the other structures on the island, most of them "inadequate and incommodious" (City Doc. 27, 1857:6). In November of 1858, the building was completed and the city poor in the House of Industry were moved into it from the wooden buildings. At this time a portion of the building was also allocated for the use of the House of Reformation. No prisoners from the House of Correction were yet sent to the island.

During the summer of 1858, the House for the Employment and Reformation of Juvenile Offenders-Boys was transferred from South Boston to new quarters at Deer Island. Boys sentenced for misdemeanors such as truancy, larceny and idleness were sent here for discipline (Snow 1971:156). Shortly thereafter, in the fall, a school for girls was established in the House of Industry and became known as the House of Reformation-Girls. Between 1866 and 1873 neglected children were transferred to the Almshouse facilities (Bradlee 1976:9-12). Also present on the island at this time, to serve the needs of children, were the Pauper Boys' and Pauper Girls' Schools within the Almshouse, serving the deserving poor. Until 1869/1870, the children were housed with the men and women of the institutions. After that date, with construction of new facilities, boys and girls were not only separated from each other, but also from adults.

The year 1877 saw a number of changes in population and institutions at Deer Island. Adult female paupers were removed to Austin Farm. The pauper and neglected boys were removed to the Marcella Street Home in Roxbury. This helped to relieve the crowded conditions at the main building. The only paupers remaining at Deer Island Almshouse following this reorganization were the young children in the nursery, pauper girls, and a few adult females too ill to be transferred with the rest (City Doc. 49, 1877:18).

In 1882, a House of Correction was established at Deer Island with the transfer of some inmates from the House of Correction in South Boston. Young men were sent to Concord Reformatory, the rest went to Deer Island. The House of Correction was not considered a reformatory, but "merely a place of punishment and detention" (City Doc. 9, 1887:34). Men were employed in many



occupations on the island, i.e. farming, stone cutting, and manufacturing of a number of items.

In Chapter 536, Section 9, of the Acts of 1896, the institution formerly known as the House of Industry on Deer Island "was established as a Suffolk County Institution, and designated as the House of Correction at Deer Island" (City Doc. 14, 1897:1). A new cell building was completed about this time, providing 500 additional cells. It was not until 1902 that the last of the inmates housed in the House of Correction in South Boston were moved to Deer Island and the consolidation completed. After this date the House of Correction was the only City of Boston institution located on Deer Island. All other inmates in the Almshouse and schools had been moved to other locations.

In 1906, following negotiations between the City of Boston and the U.S. Government, the City deeded nearly 100 acres in the southern portion of Deer Island to the federal government for the construction of a military reservation and harbor defenses (Suffolk Co. Registry Book 3177:577). Included in the stipulations of this transfer was the agreement that the City would build a boundary wall between City and Military reservation property, remove the old piggery and other City property, discontinue cultivation and removal of sand, gravel and sod, and discontinue burials in old Resthaven Cemetery on the new military reservation property (U.S. Army Corps of Engineers).

A sewage treatment plant was constructed on the island in 1889 with a major outlet into the harbor at the south end of the island. In the 1950's some 39 acres of land adjacent to the prison facilities on the south end were taken by the Metropolitan District Commission for an "antipollution and sewer project" (City Doc. 17, 1957:3). The resulting sewage treatment plant was completed in 1968.

#### **4.0 DEATH AND BURIAL ON DEER ISLAND**

Documents of the City of Boston indicate that through time Deer Island has become the final resting place for large numbers of individuals. During the forced occupation of Deer Island by "friendly" or "Christian" Indians during King Phillip's War in 1675, many of the Native Americans died. As they were not allowed to leave the island, burial of the dead presumably took place on Deer Island. Sweetser (1883:195) stated that of "500 martyrs to English distrust very many died, and were sadly buried by the moaning and misty sea." The locations of such burials were not recorded and are unknown. No evidence of Native American burials has been recovered from archaeological surveys on the island.

Prior and subsequent to King Phillip's War, Deer Island was leased by the City of Boston to a number of individuals or families (Snow 1971: 199-203). The records do not provide any details regarding deaths or interments on the island by any of these tenants. None of the early maps of Deer Island indicate locations of burials or cemeteries.

Since 1847, when the City of Boston took possession of Deer Island "for sanitary purposes", the island has been the home of various public institutions for the care of both adult and juvenile ill, poor homeless, and sentenced offenders as described above. As such, it has also been the

site of many deaths and subsequent burials of the unclaimed dead. It is on the burials and cemeteries associated with the institutions that this research focused in the effort to determine the dates, identities, methods of burial, and institutional affiliations of the interments in the new cemetery.

The initial years of the Quarantine Hospital and Almshouse at Deer Island was the period of the major influx of Irish immigrants fleeing the potato famine and disease in Ireland. Between 1847, when the institutions were established, and the end of 1849, some 4,816 persons had been admitted. Of this total number, 4,069 were ill upon their arrival at Deer Island and 759 died on the island (Abbott 1926:598). Some 721 individuals were buried on Deer Island during the years 1847-1849. These interments appear to have been made in old Resthaven Cemetery, located on the southern portion of the island, later owned by the U.S. government (U.S. Army Corps of Engineers 1908). The discrepancy between the number of deaths and the number of burials most likely indicates that some bodies were claimed by family or friends for burial elsewhere, while only the unclaimed or indigent were buried at City expense on the island.

From the initially large numbers in 1847 to 1854, deaths and burials on the island declined sharply between 1854 and 1855 along with the drop in immigration to Boston. The number of burials remained low through the Civil War years, increasing in the mid 1870's. The reason for this increase remains unclear, although general economic conditions were bad, possibly leading to greater numbers of poor being sent to the Almshouse and House of Industry.

Deaths and burials on the island decreased with slight fluctuations through the end of the nineteenth century. This reduction in the number of deaths and burials on Deer Island can probably be linked to improved sanitary conditions and health care as well as to the change in the composition of the institutionalized population. Prior to 1896, persons residing at Deer Island institutions were a varied group of men, women and children, many of whom had been living in extreme poverty conditions and were in poor physical condition, if not ill, upon their arrival. After 1896, the population at Deer Island was primarily composed of inmates in the House of Correction who had been sentenced for crimes committed, but had not necessarily been poor or ill before their arrival. In general, this latter population was healthier than those who had preceded them on Deer Island.

The records available, primarily Annual Reports of the various City committees and departments in charge of the institutions on Deer Island, provide little information about the manner in which deaths, funerals and burial were handled on the island. Even the reports of the chaplains at the institutions fail to mention deaths or burials. Only one chaplain's report was noted which mentioned that "funeral and baptismal rites have been attended to when called upon" (City Doc. 14, 1897:51).

Burial on Deer Island was referred to indirectly in several annual reports mentioning construction activities related to burials and cemeteries. In the "Annual Report of the Directors of the House of Industry and Reformation, for the year 1856-1857" construction of new tombs was reported:



The Tombs, originally located on the north easterly face of the Island, being found unsuited to their purposes, from their exposure to flooding by the action of the sea in severe storms, have been discontinued; and the material used in the construction of new ones in a more secure and suitable position. (City Doc. 40, 1857:4)

Construction of the new tombs was in an undisclosed location. In addition, during the same year, labor was expended in "digging graves for reception and depositing the bodies removed from City of Boston" (City Doc. 40, 1857:21). There is no explanation provided about how many graves were dug or where and why these bodies were removed from Boston for burial on the island.

A morgue was built on Deer Island in 1886 for the use of the various institutions as needed. The annual report for that year refers to the morgue as:

A neat and appropriate house...for temporary deposit of the bodies who may die, with room for showing the bodies to friends, and where funeral services can be performed when they are not removed for burial in other grounds (City Doc. 9, 1887:38)

Where bodies were buried if unclaimed and not removed from the island was not mentioned in the report. The first mention found in city documents and annual reports of the presence of a cemetery on Deer Island came in the 1909 "Annual Report of the Penal Institutions Department." This report, which post dates the sale of the southern portion of Deer Island from the City of Boston to the U.S. Government, makes reference to city compliance with one of the stipulations in the deed of transfer.

Owing to the taking of the land from the institution by the United States Government the creation of a new cemetery and receiving tomb were made necessary, and these have been completed. All the bodies in the old cemetery have been carefully transferred. (City Doc. 29, 1909:8).

The old cemetery referred to is "Resthaven (City of Boston) Cemetery at Deer Island" located on the military reservation property, southeast of the gate through the concrete boundary wall separating the City and Federal property on the southern end of the island.

A document and letter on file in the U.S. Army Corps of Engineers records provide information about Resthaven located from City records in 1908 (U.S. Corps of Engineers, 1908).

[Captain Fredendall] secured from the City of Boston the records showing the number of bodies interred therein and dates thereof, which show this cemetery has been used for the burial of all immigrants dying at the quarantine station or brought in from ships from 1847 to 1882, since which date it has been used for burial of criminals dying at the penal institutions, City of Boston, not claimed by relatives or friends.

Fredendall's letter further indicates that in 1908 Resthaven Cemetery contained 4,160 bodies "interred in lots of eight or ten in trenches."

If "all the bodies" in the old Resthaven Cemetery were removed to the new cemetery, presumably to the cemetery on the northeast hill behind the prison and between the piggery and the boundary wall, this new cemetery would have contained 4,160 bodies as of its creation in 1908. Subsequent deaths and burials of institution inmates would have added somewhat to that number.

Unfortunately, conflicting evidence exists in the U.S. Army Corps of Engineers records suggesting that only the eighteen bodies deposited in old Resthaven Cemetery in 1908, after the final sale of the property, were transferred to the new northeast cemetery. This is substantiated by a letter from the Master of the Suffolk County House of Correction on Deer Island dated December 30, 1908. Master Cronin reported that the 18 bodies in question, those placed in Resthaven subsequent to the sale, had been removed (U.S. Army Corps of Engineers, 1908). His letter does not indicate that "all the bodies" were transferred as stated in the annual report. This conflicting evidence raises some questions as to the exact number of bodies in the newer northeast cemetery.

A memo on Suffolk County House of Correction, Deer Island letterhead stationery dated August 23, 1934, and found inserted between pages of the Death Book maintained by the institution provided additional data concerning death and burials on Deer Island. During 1933 and 1934, ten deaths occurred among inmates. Some of these individuals had been sent to the hospital on Long Island where they subsequently died. Of the ten, four were sent to the Medical Examiner, five were claimed by relatives, and one is listed as "Unclaimed - Buried at Deer Island 7-28-34". The memo further described disposition of deceased inmates as follows:

After death, the bodies that are unclaimed are put in the tomb on Deer Island, without being embalmed, and are buried in the late summer of each year at Deer Island.

Those who die at Long Island and remain unclaimed are returned to Deer Island.

Cases sent to the Medical Examiner are claimed by relatives in most cases and rarely are the bodies of those unclaimed returned to Deer Island.

An examination of the Death Book maintained at Deer Island House of Correction since 1898 provided information on burials on the island since 1908. According to this source the last burials on the island took place in 1946. The record indicates that 97 bodies were buried on the island between 1908 and the final interments in 1946. Five of these bodies were later exhumed or disinterred, leaving a total of 92 interments. Adding these 92 additional post-1908 burials to the 4,160 reburials believed to be present in the new cemetery brings the total expected body count to 4,252.

A 1923 map of the city property on Deer Island, which accompanied a report considering relocating the State Prison to the island, showed all existing and planned structures, but did not indicate the cemetery plot nor the associated receiving tomb. Documentation indicates that the cemetery was in active use at this time. The cemetery does appear on a 1946 U.S.G.S. topographic map and on current maps.

Current practice on the island with regard to deceased prisoners is to call a Boston mortuary to pick up the body. Following an autopsy the death is logged in the prison death book and the body is either turned over to relatives or, if unclaimed, is buried in a City pauper cemetery such as Mt. Hope Cemetery (Hamilton, personal interview, 1987).

An interview with Mr. Earl Hamilton of the Penal Institutions Department, and a former Superintendent of the Suffolk County House of Correction at Deer Island provided additional evidence concerning the new northeast cemetery (personal interview, 1987).

A photograph in Mr. Hamilton's possession, roughly dated to the 1920s, appears to show the cemetery in the upper center as a large area stretching from the piggery to the boundary wall and tightly filled with white wooden crosses. Judging by this photo it appears likely that indeed all 4,160 bodies from old Resthaven had been transferred and reinterred in the new Resthaven cemetery above the Hill Prison building.

A number of photographs obtained from Alfred K. Schroeder at the archives of the MDC in Boston show New Resthaven Cemetery in the background. One photograph labeled "Sept. 1939, Naval Direction Finder Station, Deer Island" shows the cemetery on the slope behind the Hill Prison building. Approximately 79 white crosses are clearly visible on the slope above the mausoleum and immediately adjacent to the cement boundary wall. The slope area further northeast, closer to the piggery, appears as a rectangular blurry white area. It is unclear whether this was due to a large number of white crosses, or whether the area had been excavated or somehow disturbed. Other pictures probably dating to the 1940s definitely show a white picket fence forming the northern boundary of the cemetery and separating it from an apparently empty field extending to the piggery. At least some of the white wooden markers remained standing in a 1958 photograph. By 1963, most of the individual wooden crosses were gone, leaving only the larger concrete cross which remains today.

Mr. Hamilton (personal communication) knew of no reason to believe that these bodies had been removed from the island since the pictures were taken, even though sometime prior to the 1970s the practice of sending details of prisoners to paint the crosses and maintain the cemetery had ceased. The condition of the cemetery had been allowed to deteriorate until it was barely recognizable as a cemetery in 1985.

## **5.0 GEOPHYSICAL/REMOTE SENSING SURVEY OF CEMETERY AT DEER ISLAND**

Electrical resistivity and proton magnetometer surveys were conducted at Deer Island as part of an archaeological locational survey for The PAL, Inc. The process of geophysical survey was chosen for its ability to detect subsurface disturbance in the soil and guide excavation for the location of unmarked burials.

Geophysical survey has been used as a locational tool in archaeology since the late 1940s. First used extensively in Britain, both the equipment and the method have been developed and refined over the years. Background and development information can be located in the

literature (Aitken 1958, 1974; Atkinson 1946, 1963; Breiner 1973; Carr 1976, 1977, 1982; Eve and Keyes 1954) and an increase in field use can be evidenced by recent publications (Frese 1984; Frese and Noble; Klasner and Calengas 1981; Mason 1984; Parrington 1979, 1983; Shapiro 1984; Weymouth 1976, 1979, 1986; Weymouth and Nickel 1984; Weymouth and Woods 1984).

A number of rectangular and square blocks were surveyed in the project area using two geophysical methods, as these two methods are sensitive to different properties, and a complete geophysical archaeological survey should include multiple methods (Gumaer et al. 1984a).

Figure P-2 shows the location of the testing units used during the sensitivity testing. A total of eleven 20 x 20 m blocks or partial blocks were surveyed (labeled #1 - #11) as well as a large rectangular unit (labeled OMNI). The eastern edges of Blocks 3, 4 and 5 were reduced in size due to the presence of the eroded embankment. Block 5 is small due to time constraints, while Block 7 was shortened by the concrete boundary wall. Electrical resistivity was measured in Blocks 1 through 10. Proton magnetometer readings were taken in Blocks 1, 2, 8, 11 and OMNI. Measurements were taken at one meter intervals along both the X and Y coordinates of one meter interval grid blocks. Data was entered into a computer and analyzed through the use of the computer graphics program SYMAP (Dougenik and Sheehan 1975).

## 5.1 ANALYSIS OF GEOPHYSICAL DATA: EXPECTED TARGETS

Locating areas of anomalous variation in geophysical data is a problem of spatial patterning. An area will have natural variation affected by its soil makeup. Human activities which penetrate the ground surface can change aspects of the soil which can be detected by geophysical prospecting. The particular target for this field survey was the location of unmarked burial remains within an area known to be used as a cemetery during historic times. Background research showed that the majority of the remains had been moved to this location from another area in 1908 while the rest are the remains of prisoners from the adjacent prison. While both groups of burials would leave behind similar subsurface disturbance, those moved from another cemetery after already having been in the ground for a number of years, in many cases without a coffin, may not be in singular graves and would disturb a larger area.

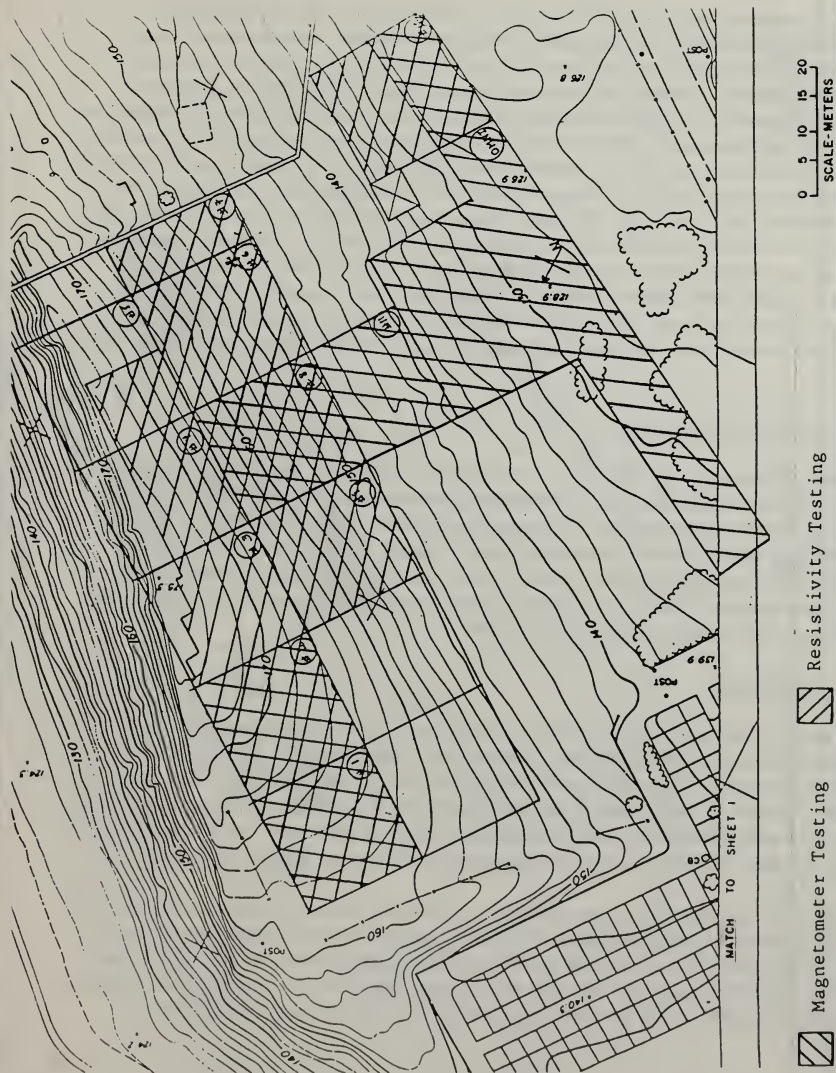
## 5.2 RESISTIVITY

Moisture content, granular size, density, and chemical content are factors which contribute to soil variations which are detectable by resistivity survey. The shaft feature from the excavation and refilling of a burial will be detectable as higher resistance. Even after hundreds of years, the soil within the shaft will contain more air space between granules than the surrounding soil. This results in a reduction in conductivity which registers as higher resistance. This type of anomaly has enabled the location of similar grave features elsewhere in New England (Gumaer 1985).

## 5.3 MAGNETOMETER

Mineral content of soil, specifically the presence of magnetite or related minerals, will





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**FIGURE P-2  
LOCATION OF SENSITIVITY TESTING UNITS**

affect its magnetic susceptibility (Breiner 1973). Soils and rocks may be magnetically enhanced by induction or by remanence. Induced magnetization is directly related to the percentage of magnetite in the soil or rocks. Naturally occurring features such as large boulders containing magnetite can also create a strong enough field to be seen as dipole or monopole anomalies. Anomalies targeted during surveys of prehistoric features are largely the result of thermoremanence. Soils or rocks are heated in a reused fire hearth and the heating allows the magnetic properties or domains (Aitken 1961:18-19) of the minerals within to become unfixed and gravitate towards alignment with the earth's magnetic field. Upon cooling, the properties are fixed once again. The more reheating episodes, the stronger the magnetic field in the soils and rocks are enhanced (Tite and Mullins 1971:216-217). Anomalies caused by the digging and refilling of holes will mix the magnetic domains of the soil and will register as areas of slightly lower magnetic intensity. Historic burials may also offer a different target anomaly if a coffin is used which contains metals having magnetic properties such as iron. With this in mind, areas both above and below the mean will be of interest for the Deer Island data.

#### 5.4 COMPUTER SOFTWARE

SYMAP can be used to produce contour representations of the data as well as to manipulate the data with smoothing routines such as nearest neighbor averaging and trend surface analysis, plotting the trend or the residuals. This type of preliminary analysis can be useful in filtering out natural variation and locating areas of interest that can be field checked. While newer, more sophisticated methods of gray scale have been shown to enhance thin line geometric structures (Scollar et al. 1986), standard contour-type computer plotting is still an inexpensive and rapid first technique for analysis.

#### 5.5 ANOMALIES

A number of anomalies were located as a result of the two techniques employed during the geophysical survey. Figure P-3 shows the locations of these anomalies. It is keyed to indicate anomalies of different relative sensitivity or priority. The high priority areas are those anomalies with the greatest probability of reflecting the presence of burials. Anomalies of low or medium sensitivity were considered more likely to reflect other types of disturbance, such as building debris, fence lines, or change in slope, soil type, or moisture content.

Two anomalous areas were of special interest. These were the high priority anomalies in Block 8 and in Blocks 6 and 7. The pattern of relatively small, discrete anomalies between the 164-foot and 148-foot contour lines in Block 8 strongly suggested the presence of individual burials. The large anomaly in Blocks 6 and 7, up the slope from the concrete cross, suggested the possible location of a mass burial, possibly the early twentieth century reinterment.





FIGURE P-3  
ANOMALIES LOCATED DURING GEOPHYSICAL SURVEY, DEER ISLAND

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## 6.0 SUBSURFACE TESTING

The final stage of the intensive survey was the subsurface testing of the cemetery site. A site verification testing plan was developed based upon the data collected during the in-depth documentary research and the remote sensing results. The primary objectives of this fieldwork included:

- (1) Determination of the horizontal extent of the cemetery through systematic subsurface testing.
- (2) Collection of sufficient data to reconstruct the internal configuration or plan of the cemetery and general mode of burial (individual graves, multiple burial in trench, etc.) used at this site.

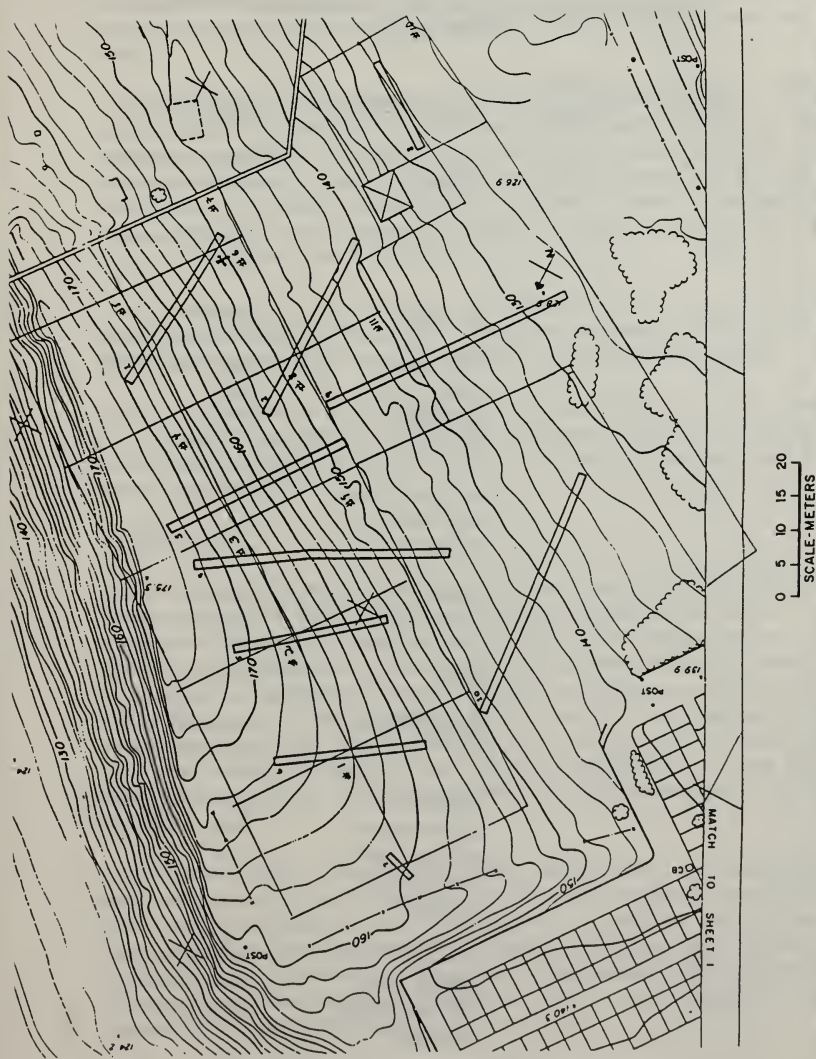
In 1987, the hillside between the concrete boundary wall and the piggery show few evidences of the old cemetery. The stone and brick mausoleum remains, as does the white concrete cross standing on the slope above. The grass appears more lush and green with fewer coarse weeds immediately above the mausoleum and adjacent to the boundary wall. The portion of the field nearer the piggery is covered in coarser grass and weeds which in some areas are very low and in others fairly high. The ground surface is strewn with historic sheet refuse, including broken pieces of hotel or institutional hardwhite ceramics, glass, metal fragments and a few pieces of wood. The amount of surface historic trash seems to increase with distance northeast from the concrete boundary wall and cross. These may both be indications of the location and northeastern boundary of the cemetery.

### 6.1 TRENCHES

A total of ten trenches were excavated using a combination of machine-assisted and hand excavation techniques. Figure P-4 shows the locations of these trenches, which were aligned to cover as much of the project area as possible. Due to the sloping surface of the hillside the location and alignment of several trenches were changed slightly in the field to accommodate the backhoe. Trenches 1 through 6 were placed to examine the extent and configuration of the cemetery in general and specific anomalies located by the remote sensing survey in particular. Trenches 7 through 10 were laid out to test the cemetery boundaries indicated on the 1920s photograph of the cemetery. They extend beyond the documented boundary to include marginal areas that might have been used as a burial ground before and after the date of that photograph.

The trenches were excavated by backhoe only to a depth thought to be sufficient to identify a filled burial shaft or mass burial. The depth of the trench beneath ground surface varied, but never exceeded 1.5 m.

The results of the trench excavation are detailed in Table P-1. With the exception of Trenches 1 and 8, the soil matrix was a medium brown, very rocky to gravelly sandy loam (A2) overlying a yellow to orange brown, loamy to coarse sand subsoil (B1). Soils upslope, above the 140 foot



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FIGURE P-4  
LOCATION OF MACHINE EXCAVATED TRENCHES

**TABLE P-1**  
**TRENCHES EXCAVATED DURING SUBSURFACE TESTING,**  
**DEER ISLAND**

<u>TRENCH NO.</u>	<u>LENGTH (M)</u>	<u>FEATURE NO(s)</u>	<u>SOIL CONDITIONS</u>	<u>ARTIFACTS</u>
1	26.5	1 & 2	medium brown sandy loam	hardwhite, porcelain wood, nail
2	30	-	rocky upslope	hardwhite animal bone
3	26	-	very rocky	hardwhite
4	39	-	heavy, gravel upslope; rocky sandy loam downslope	hardwhite, animal bone
5	24	-	very rocky; some large rocks shallow A2	hardwhite
6	23	-	gravelly	hardwhite, milk glass
7	5	-	rocky	hardwhite
8	15	-	deep silty loam	hardwhite, nail animal bone
9	40	4	rocky soil upslope; clayey on slope, darker less gravelly downslope	hardwhite, stoneware flatware, animal bone
10	38	3	very rocky upslope, thick dark sandy loam downslope	hardwhite, glass, shell, much animal bone



contour line, tended to be coarser and more rocky than those on the lower portion of the slope. Trench 8, located in front of the mausoleum near an old pond/wetland, had a much thicker medium-to-dark-brown silty loam topsoil. Trench 1, even though it was located upslope, above the 150 foot contour line, had a thick medium-brown, sandy loam topsoil without rocks or gravel.

At least a small amount of hardwhite ceramic, nineteenth to twentieth century hotel/institutional ware, along with some porcelain, glass, and metal fragments, was found in each trench. It was found in greater amounts in Trenches 3-10 than in Trenches 1 and 2. Butchered animal bone, primarily cow and pig, was found in Trenches 2, 4, 8, 9 and 10. The largest amount of this bone was located near the lower end of Trench 10 where most of a pig skull was recovered. Decayed wood and a nail were recovered from the lower end of Trench 1 near the concrete cross (Table P-1).

Shovels and trowels were used to scrape down and clean off trench walls in an effort to locate possible features and for recording profiles. In addition, the bottom of trenches was shovel-scraped in areas which showed the potential to yield additional information.

A total of four features was located (Figure P-5). Two were located in Trench 1, Features 1 and 2. Feature 3 was discovered in Trench 10, and Feature 4 in Trench 9. Only Features 1 and 2 appeared to be related to the cemetery (Figure P-6). After close examination both were determined to be graves.

## 6.2 FEATURES

Feature 1 was located at the lower end of Trench 1 some 2 meters south of the base of the concrete cross. It first appeared in the trench profile as a slightly darker, mottled orange-brown and dark brown sandy soil containing some wood fragments and one coffin nail (Table P-2). The trench floor was shovel-scraped and troweled and the area of dark soil could be seen extending approximately .75 meters across the trench floor to an apparent corner (Figure P-7). A .5 x .5 meter judgemental shovel test pit (JTP 1) was excavated into the feature. Excavation of this unit proved that Feature 1 was a grave shaft containing a badly deteriorated wooden coffin and poorly preserved human bone (Figure P-8). Both the wood and bone were soft and spongy. The coffin appeared to be oriented perpendicular to the slope of the hillside.

A second grave, Feature 2, was located in Trench 1 above Feature 1. As with Feature 1, this grave shaft was first noted in the profile of the south wall of the trench as an area of mottled medium and dark brown sandy loam (Figure P-7). The trench floor was then shovel-scraped and troweled to determine the orientation of the grave shaft. Feature 2 also appeared to be a roughly rectangular feature oriented perpendicular to the slope of the hillside. Based upon the results of the excavation of JTP1, it was not considered necessary to excavate a similar unit in this feature.

Feature 3, located between the 142 foot and 144 foot contour interval on trench 10, was a different type of feature (Figure P-5). This distinctive feature consisted of a band of dark

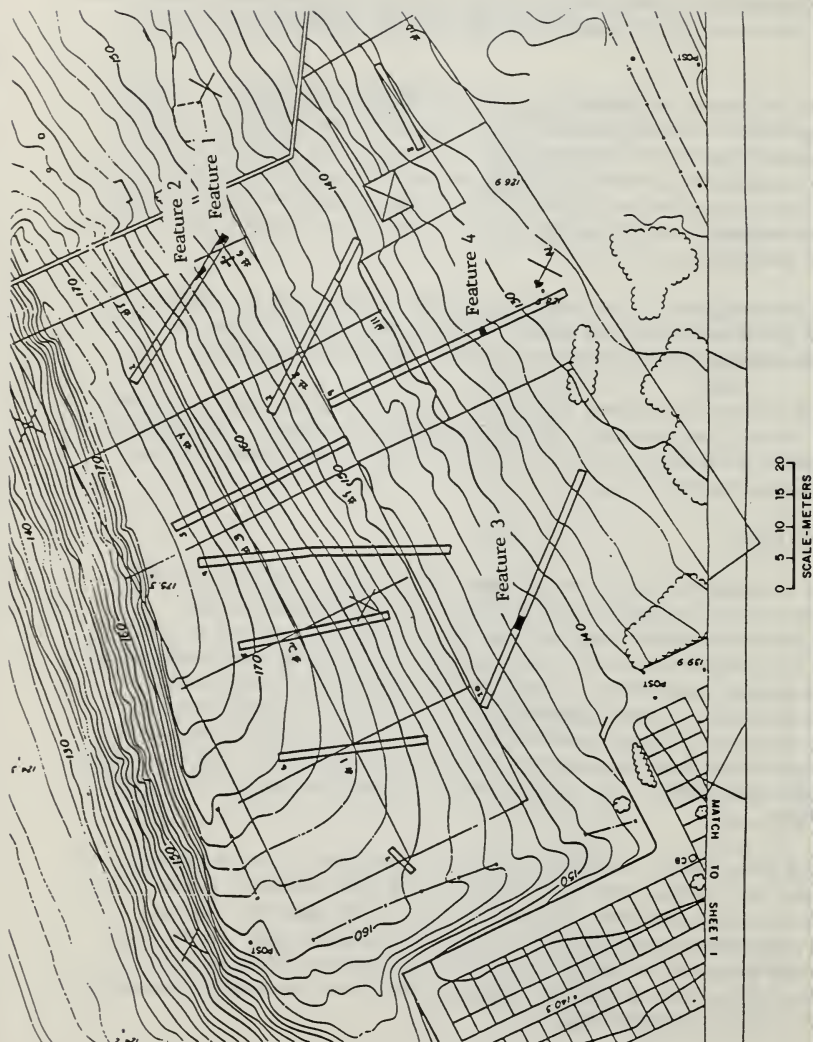
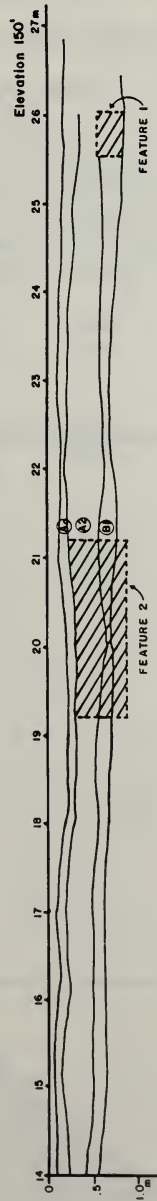
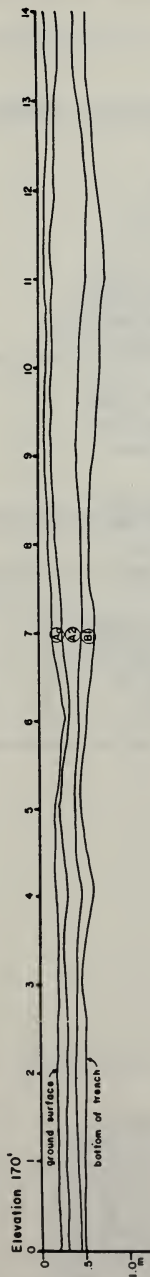


FIGURE P-5  
LOCATION OF FEATURES

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Profile Trench 1, South Wall



A2: duff/hod  
A2: medium brown sandy loam  
B1: tan/yellow brown sand

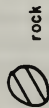
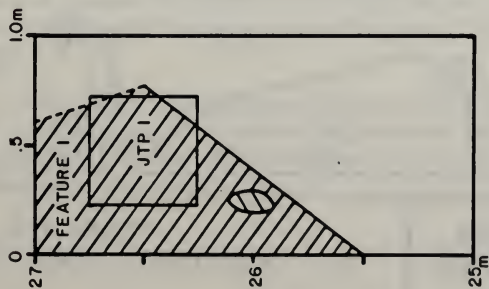
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FIGURE P-6  
TRENCH 1 PROFILE

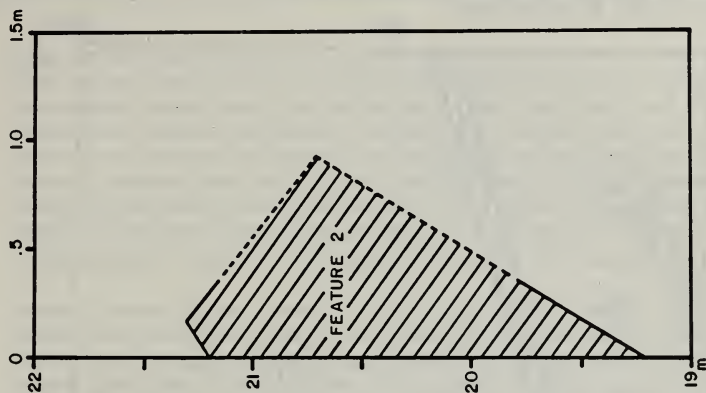
TABLE P-2  
FEATURES LOCATED DURING SUBSURFACE TESTING,  
DEER ISLAND

<u>FEATURE NO.</u>	<u>TRENCH NO.</u>	<u>TYPE</u>	<u>SOIL</u>	<u>ARTIFACTS</u>
1	1	grave	mottled orange and dark brown sandy loam	coffin wood and nail, bone
2	1	grave shaft	mottled medium and dark brown sandy loam	none
3	10	possible drain	distinct areas of rocks and dark brown silty loam	metal tankard, shell, metal, stoneware
4	9	possible trash pit	mottled medium brown and dark brown	animal bone, metal

Plan view Trench 1, Feature 1  
at lower/west end of trench



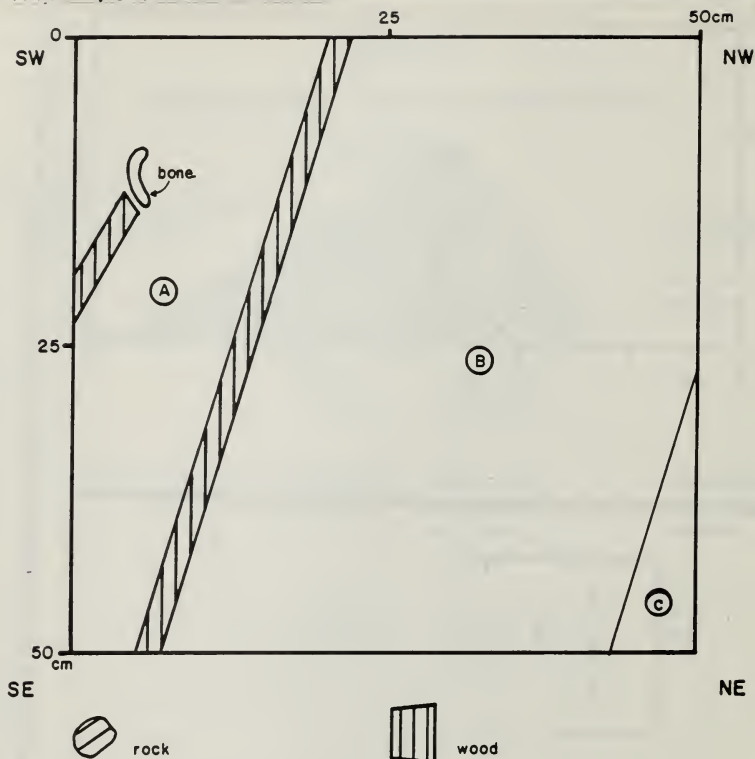
Plan view Trench 1, Feature 2



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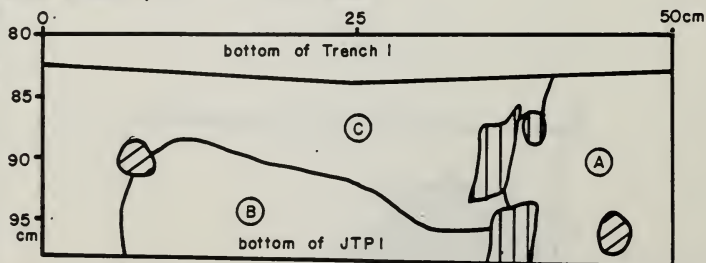
FIGURE P-7  
TRENCH 1, FEATURES 1 AND 2 PLAN VIEWS

Plan view Trench I, JTPI at 97cm dbb



- A: mottled medium and dark brown  
 B: mottled orange brown and dark brown  
 C: mottled yellow brown

Profile Trench I, JTPI of East Wall



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FIGURE P-8  
 FEATURE 1, JTPI, TRENCH 1

brown silty loam approximately 1.0 to 1.25 meters wide running across the trench floor adjacent to and upslope from an area of loosely packed rocks (Figure P-9). The top of the rocks began approximately .8 meters below the ground surface and they extended down some 30 to 60 cm. A small amount of clam and scallop shells, metal fragments, one piece of stoneware, and what appeared to be a crushed metal tankard were found between and among the rocks (Table P-2). Feature 3 is possibly a drain used to channel runoff from heavy rains, and/or seawater wash during high seas, from the lower slope and portion of the inland currently housing the prison. This feature could date to a pre-institutional occupation of the island, or to the early institutional period. Feature 3 does not appear to be related to the cemetery.

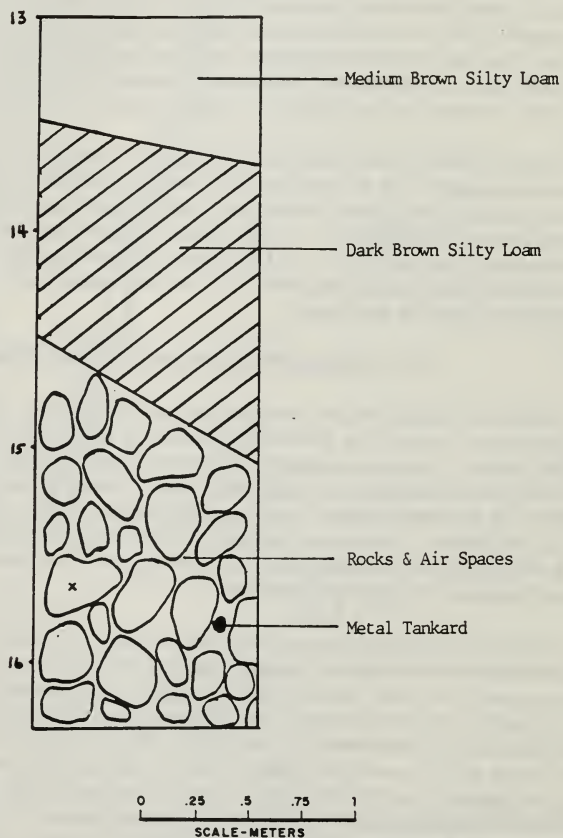
Feature 4 is a small pit feature located in Trench 9 (Figure P-5). It consists of a pit extending from approximately .2 to .8 meters below the ground surface and 1.0 meters wide (Figure P-10). The upper portion of the pit was filled with a mottled brown sandy loam while the lower portion was dark brown in color. A small amount of greasy black charcoal was visible along the line separating these two layers of pit fill. A piece of animal bone and a fragment of metal were located within the upper fill (Table P-2). Feature 4 appears to be a small trash pit and is probably not related to the cemetery.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

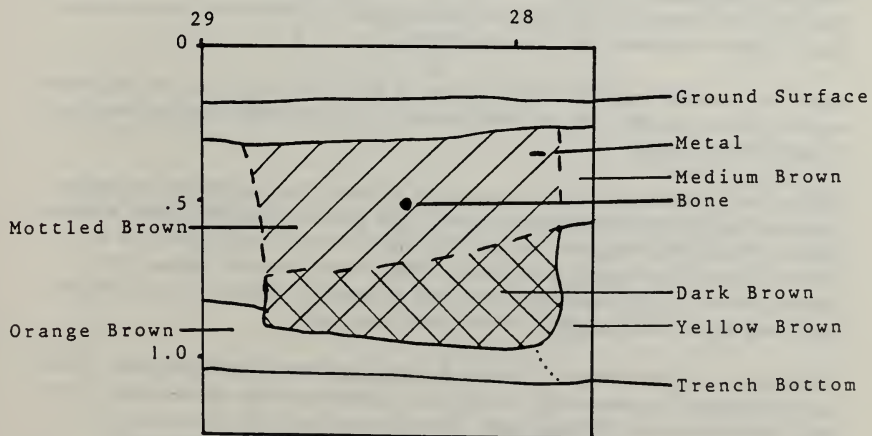
The primary goal in this research has been to discover as much information as possible concerning the cemetery located on the northeast slope behind the Hill Prison building on Deer Island in Boston Harbor. The major questions examined have related to the age of the cemetery, its period of active use, its institutional affiliation, the number of individuals buried, the method of burial, the size of the cemetery, its horizontal boundaries, and the internal configuration of the cemetery. Documentary evidence provided information on many of these questions. Remote sensing and subsurface testing were less successful, but did substantiate the presence of burials in a portion of the project area.

During the course of the in-depth documentary research, contradictory evidence was uncovered concerning the origins and development of the northeast cemetery. After consideration of all the evidence it appeared most likely that the cemetery in question is "New Resthaven Cemetery" created in 1908 with the reinterment of some 4,160 bodies from old Resthaven Cemetery in the military reservation on the southern portion of Deer Island. The cemetery, at its present location, is 79 years old, or greater than 50 years in age. In addition, 2,559 of the bodies reinterred in new Resthaven are 100 years in age or older, many of them being quarantine hospital victims and Irish immigrants. An additional 92 unclaimed bodies were interred in the cemetery subsequent to its creation. The last recorded burials on the island occurred in 1946 (Deer Island House of Correction Death Book). As no evidence has been found suggesting the removal of these burials to another location, it is expected that some 4,252 bodies remain interred in the cemetery.

The documentary research initially suggested that the northeast cemetery plot, or New Resthaven, was potentially much larger than expected from the cursory field inspection of the site. Judging by the 1920s photograph, the cemetery appeared to extend from the northeast wall







of the old piggery to the cement boundary wall and from the sea wall at the top of the slope to the mausoleum at the foot of the slope.

The 1939 and 1940s photographs, acquired recently, show less extensive cemetery boundaries. This smaller cemetery plot is restricted to the portion of the slope above the mausoleum, from the cement boundary wall northward approximately 30 to 40 meters to a picket fence.

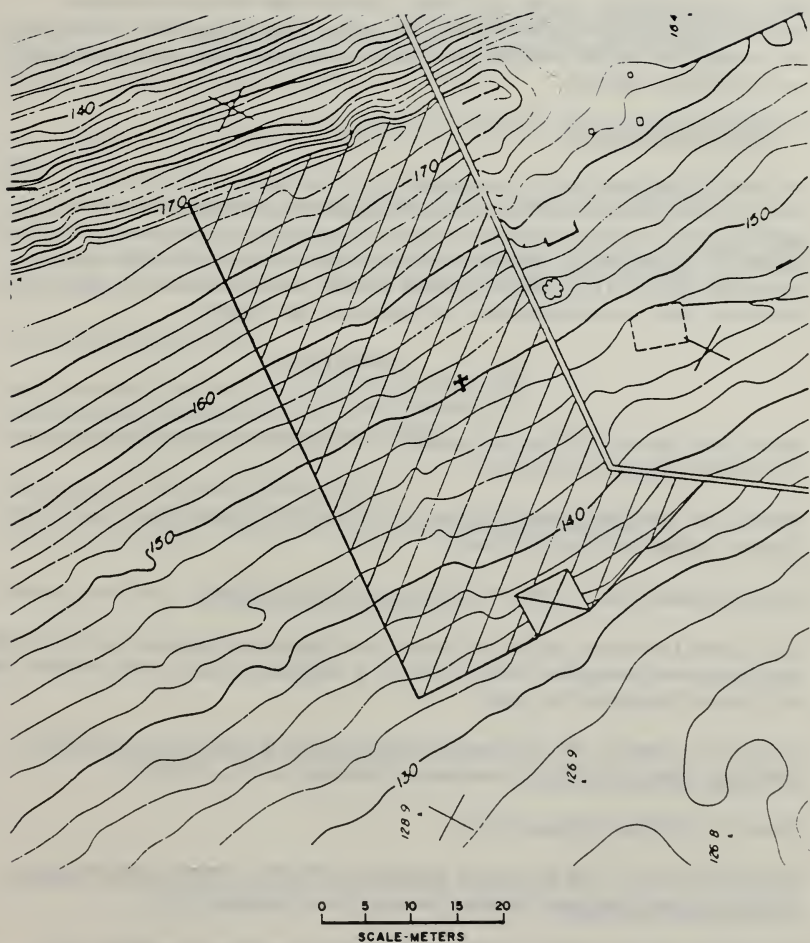
Archaeological fieldwork tended to confirm the smaller cemetery boundaries. Only Trench 1 produced features related to the presence of an historic cemetery within the area examined by the subsurface testing. Trench 2, even though located in a position to cross the cemetery boundary, as indicated on the 1939 and 1940s photos by the white picket fence, did not provide evidence for this boundary. No grave shaft features were located in Trench 2 or in any of the other Trenches 3 through 8. This suggests that the cemetery did not extend more than a short distance beyond the northeast edge of the mausoleum.

Figure P-11 shows the probable revised boundaries of the cemetery based upon the documentary and subsurface testing data. The northwest boundary is an approximation primarily based upon the photographic evidence.

Evidence for the internal configuration and mode of the cemetery was provided by the historic photographs and the locations of Features 1 and 2. The presence of a gridded pattern of wooden crosses in the historic photographs suggest individual graves packed close together. As no evidence has been found suggesting the removal of these burials to another location, it is expected that some 4,252 bodies remain interred in the cemetery. However, it is also possible that crosses marked bodies buried in trenches or in a mass burial.

An attempt to count the number of crosses in the photographs led to another possibility. There were approximately 79 crosses in the area above the mausoleum between the concrete wall and picket fence visible in the 1939 photograph. This correlates closely with the total of 92 bodies buried on Deer Island after 1908. It is possible, therefore, that the burials and crosses correspond to these 92 "new" (1908 to 1946) interments. This leaves the location of the reinterments unclear. Considering the incredibly poor preservation of the wood and bone in Feature 1, and the large, otherwise unexplained anomaly in Blocks 6 and 7, it is possible that the reinterred bodies were buried in a mass grave in this location in 1908. Subsequent burial of the more recent bodies and the intervening 79 years may have erased most evidence of these 4,160 reinterred bodies.

A number of factors may have combined to cause the poor preservation exhibited by the burial in Feature 1 and by the general lack of visible burials. First is the age of the burials, especially the reinterments. The majority of the burials predate 1850. Second, there is no evidence to suggest that any of the bodies were embalmed before burial. Indeed, the 1934 memo indicates that this was not done in the more recent period. Third, it is highly unlikely that the earliest, and therefore the majority, of the burials were interred in coffins. This could tend to detract from preservation potential. Fourth, no information was located concerning the methods used to exhume and then reinter burials in 1908. It is unlikely that great care was



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FIGURE P-11  
REVISED BOUNDARIES OF NEW REST HAVEN  
CEMETERY, DEER ISLAND

taken in their transferral. Finally, the cemetery's location on the bluff near the Atlantic ensures the frequent drenching of the plot by salt water and spray during storms and high seas. The corrosive nature of salt water may have contributed to the poor preservation of the burials in New Resthaven Cemetery.

## 7.1 RECOMMENDATIONS

No further archaeological work is recommended at the New Resthaven Cemetery on Deer Island. Due to the poor preservation of the burials in the cemetery, it is unlikely that burial of the cemetery under a soil beam could cause much further damage than nature appears to have already caused. As no indications of interments were encountered except in the small area above the mausoleum (Figure P-11) construction activities below the mausoleum, below the 148 foot to 150 foot contour lines, are unlikely to cause any disturbance to the cemetery.

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